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Farming with Hope . . .

FARMERS with the American right to "life, liberty, and pursuit of happiness" look to rural electrification for new tools with which to work toward these ideals. Electrification offers the hope of greater security for life, from infancy to retirement; of liberation from drudgery, darkness, and physical limitations; of time, means, devices, and outlook for effective work and play in the pursuit of happiness. Power lines increase the hope. Agricultural engineers increase its soundness.

AGRICULTURAL ENGINEERING

VOL 19, NO 6 EDITORIALS JUNE 1938

Annual Meeting Program Indications

INDICATIONS of the current trend of agricultural engineering interest, as seen in the A.S.A.E. annual meeting program, appearing in our May issue, show a sustained major emphasis on farm operations, methods, and operating equipment. Agricultural engineers are keeping close to the soil; close to immediate, practical farm operating problems and the immediate next step of progress farmers may be prepared to take.

Specific crops, commodities, and types of farming to be considered in the program, as suggested by titles listed, include corn, cotton, grapes, fruits, milk, peas, potatoes, poultry, and vegetables. Additional items may show up in the completed papers. The list is small, and the titles indicate consideration of specific individual problems in each case. This may or may not indicate a trend toward increased special consideration for specific types of farming or the production of specific crops and commodities, and the relative importance and interrelationships of the agricultural engineering problems involved therein. This line of approach has previously been suggested and practiced by some few agricultural engineers, and would seem to warrant further consideration.

"Before" and "after" testimonials to the economic and social significance of various agricultural engineering developments will occupy their usual place, along with the philosophy of technological progress in agriculture, as the main burden of some general papers and the starting and end points of more technical contributions.

Technical engineering progress in the development of data, organization, and controls, preliminary to applications on farms or in farm equipment, will be noted in more than a dozen papers and reports, indicating a continuing close tie-up of agricultural engineers with the basic sciences which they utilize.

The College Division program is loaded with the subject matter of professional development, including personnel training, curricula, student branches, teaching methods, research outlook, extension effectiveness, the direction of agricultural engineering technology, and the agricultural engineering opportunities seen in new trends of science and public opinion.

This is the cross section of current agricultural engineering interest indicated in a program of, by, and for agricultural engineers. How nearly it may represent optimum application to their greatest opportunities, none can say. However, as long as they get together frequently, and consider their past, present, and future from numerous angles and viewpoints, there seems little danger of their falling into any serious ruts.

Appraisal of Engineering Values

IN THIS time of social and economic unrest the appraisal of engineering contributions to social and economic values has assumed the proportions of a major problem.

The public is being harangued by all manner of agitators, antagonists, protagonists, and prognosticators; by the supposedly well informed, the uninformed, and the misinformed, the sincere and the insincere. It is being urged to viewpoints, actions, and support of proposals which engineers believe will be detrimental to the public through detriment to engineering progress, witness the proposed limitation of patent rights. It is in a mood to try to improve conditions and is looking for information and guidance which can be trusted.

The man-on-the-street is not interested in engineering, economics, or sociology as such. He is interested in getting along in the world, and in the laws and business conditions which influence the progress of his individual welfare. If he is to lend the weight of his opinion in favor of unhampered engineering progress, its meaning to his welfare must be made clear. It must be appraised in words he can understand.

How this may best be done is a question. It is true that many thinking people share with engineers a firm conviction that, in general, engineering developments have contributed great positive values to individual and collective human welfare. But where is their proof? What would be a fair basis of appraisal? What would be a satisfactory unit of social value? How about differences of opinion between engineers as to the values of certain engineering works and developments? Is there a widely distributed, readable, nontechnical, summation of what engineers agree to be their important contributions to the comfort, safety, prosperity, and general wellbeing of John Q. Public?

We submit for consideration the desirability of engineers summarizing the points on which they agree as to the manner and extent of engineering contributions to widespread individual welfare. Important matters of opinion upon which engineers do not agree might also be summarized for the sake of identifying them publicly as controversial, and of avoiding public misconception as to the whole engineering profession supporting any one side of any unsettled public question.

American Engineering Council has, in its recent public forum and other activities, made an excellent start in calling public attention to engineering opinion, both united and controversial, on matters of public affairs. It is hoped that this can be continued and enlarged until everyone who can read can easily know what engineers think on engineering matters concerning his welfare, and the evidence upon which they base their conclusions.

Engineers may safely smile at the mere verbal abuse heaped upon them by a loud minority, if they can help the solid majority to a true appreciation of how engineering helps the public.

Two-House Farms

FARM BUILDINGS men may find it interesting to play around a bit with the idea of the two-house farm, or even to work on it seriously.

An additional house will increase the farm investment overhead as much as a large tractor, several small ones, a substantial barn, or an additional "forty" in many cases. But it may be worth the cost in many instances from economic as well as sociological viewpoints.

While maintaining a comparatively safe distance between "in-laws," it may save the squire of the homestead from unwelcome retirement to the circle of cracker-box politicians in the neighboring village. Or vice-versa, it may save the son or son-in-law from retirement to the WPA.

From a practical operating standpoint it may save more than its cost by minimizing the transient labor problem. One satisfied dependable worker on hand may be worth two or more knights of the road.

The idea of equipping numerous farms with additional satisfactory, low-cost houses opens an interesting opportunity to agricultural engineers and the building materials trade to meet the design problem involved. For some farmers and some extension agricultural engineers it may provide the initial satisfactory contact which will open the way for collaboration in the solution of other farm problems.

Agricultural engineers should be able to give farmers material assistance in determining the conditions of labor requirement, investment cost, and comparative adequacy of other farm operating equipment which will justify an additional house as an element of overall farm operating efficiency.

Correct in Principle

To the Editor:

Your arguments in favor of low tariff are correct in principle, but there is no proof that low tariff, considering the world situation realistically, will restore the stable flow of international commerce, devoutly as we might wish it in the interest of social progress.

The agricultural engineer, however, needs not be conscience stricken for the surplus he helped create; the synthesis of the trends of all basic factors of civilization opens up opportunities for the agricultural engineer, many of him, and the farm equipment industry, such as the foreign trade never approximated.

Philip Weiss

Philadelphia, Pa.

THE REALISTIC viewpoint of this correspondent is acknowledged. It will be difficult, if not impossible, to restore the trade volume destroyed by restrictions. We have invited competition which will not readily drop out of the race, even on removal of the restrictions which gave it a start.

However, anything that American agricultural engineers, farmers, and the farm equipment industry can do to further lower farm costs of production will make American farm products more attractive to the world, as well as to the domestic market. Perhaps that, then, is the brightest hope for American farmers and all who depend on their trade. Still, it looks as if anything that can be done to reduce artificial trade restrictions will help.

"Farm Refrigerated Storages"

To the Editor:

WE HAVE just recently obtained a copy of the December 1937 issue of AGRICULTURAL ENGINEERING and have read the article entitled "Farm Refrigerated Storages", by Mr. Earl L. Arnold, and would like to comment on it as far as it concerns the refrigerant "Freon-12" mentioned on page 552.

Fluorine-bearing compounds used as refrigerants and manufactured by us are known as the "Freon" family of refrigerants which is made up of a great number of compounds or members of that family. Such fluorine refrigerants that are being very widely used throughout the refrigeration industry are dichlorodifluoromethane, CCl_2F_2, commonly known as "F-12"; dichlorotetrafluoroethane, $C_2Cl_2F_4$, known to the trade as "Freon-114"; trichloromonofluoromethane, CCl_3F, known as "Freon-11" and many others. Thus "Freon" covers the entire group of fluorine refrigerants, while Freon-12 identifies but one member.

The statement is made that slightly more refrigeration can be obtained per unit of power with ammonia than with either methyl chloride or Freon. We do not agree with this statement, as it is a well established fact that the horsepower per ton of refrigeration is substantially the same for all refrigerants with the possible exception of carbon dioxide. If you will refer to the A.S.R.E. Data Book 1937-38, page 63, horsepower-per-ton figures are given by two authorities which are completely substantiated by the engineers throughout the industry.

It is stated in the article by Mr. Arnold that the use of ammonia may result in longer life of the machinery. We very much disagree with this statement for the reason that Freon-12 compressors operate at lower pressures, 93 lb vs 154 lb per sq in, at 86 F (degrees Fahrenheit). Freon has a lower temperature of compression, 109.5 vs 222.6 F under standard ton conditions. Freon compressors have lower bearing pressures. Freon-12 charged compressors have lighter weight of moving parts. Freon-12 is non-corrosive to all metals, which permits the use of Babbitt metal for bearings and non-ferrous metals, while the ammonia system is limited to iron or steel bearings. Lower pressures, temperatures, weights, and the use of more desirable bearing metals obviously will result in longer life to mechanical refrigeration equipment.

We would like to clarify the point as to the tendency of Freon-12 removing scale and corrosion from metal parts. Freon-12 is non-corrosive to all metals as previously stated, but has a cleansing action on metals and will physically remove scale, oxide, factory dirt, or other foreign matter from a surface with which it may come in contact. To prevent this foreign matter from entering the lubricating system of a compressor all that is necessary is to install suitable strainers or filters which are used or should be used on any mechanical system regardless of the refrigerant used.

Freon-12 has never been advertised as a perfect refrigerant, but has been referred to by the entire industry and ourselves as a "safe refrigerant" and the nearest approach to the ideal yet discovered. These statements can be made for the reason that the Freon refrigerators are odorless and non-irritating, non-toxic, non-flammable, non-explosive, non-corrosive, stable and inert, and have good chemical, physical, and thermodynamic properties for use in mechanical refrigeration systems that are now being built. As a result the Freon refrigerants will not produce a panic, health, fire, or property damage hazard.

We object to the gratuitous statement that Freon-12 breaks down into harmful products of decomposition when exposed to flames of high temperature, without mentioning the fact that all compounds used as refrigerants will do the same thing under laboratory sets of conditions and not necessarily under habitable conditions. Such a statement as was made is decidedly negative and should never be used. We refer you to a paper, entitled, "Decomposition of Dichlorodifluoromethane by Flames", presented by Dr. Thomas Midgely, Jr., and Albert Henne before the Division of Industrial and Engineering Chemistry at a meeting of the American Chemical Society, at New Orleans, 1932. Additional information may be found in various other articles on Freon and in Underwriters' Laboratories reports.

R. J. Thompson
Refrigeration Engineer

Kinetic Chemicals, Inc.
Wilmington, Delaware
May 13, 1938

Vapor Pressures in Studying Moisture Transfer Problems

By H. J. Barre

USE OF vapor pressures offers an approach to problems dealing with the transfer of moisture, which should be given more consideration than it has received heretofore. Although rather extensive data is available on the equilibrium moisture content of hygroscopic materials at various relative humidities, the information has not been applied in as meaningful and usable a sense as it might have, for purposes for which some of the data were intended. It is the aim of this report to show how vapor pressures may be used with present available data, and to point out their usefulness in studying some problems dealing with the transfer of moisture in the vapor form. The vapor-pressure relations for water vapor and hygroscopic materials will be dealt with before proceeding to the problems of moisture transfer.

Vapor Pressure — Temperature Relations for Water Vapor. Vapor pressures of saturated water vapor at different temperatures are available in published literature (11)*. These may be considered as steam pressures at low temperatures. Inasmuch as relative humidity may be defined as relative vapor pressure, that is, the ratio of the actual pressure to that at saturation, the pressures at different percentages of saturation may be readily determined. The accompanying chart shows these relationships in graphical form for various relative humidities. The broken curve represents the maximum vapor pressure above ice, which is somewhat less than that above water. The chart likewise may be considered as a superheated steam chart at low temperatures. It may also be considered as a psychrometric chart and may be used in this manner, providing the data for the wet bulb readings were supplied. For example, the tables published by the U. S. Weather Bureau (8) enable one to determine the dew point and the actual vapor pressure from the wet-and-dry bulb readings. The relative vapor pressure (relative humidity) is then the ratio of the saturation pressure at the dew point to that at the dry bulb temperature.

VAPOR PRESSURE INDEPENDENT OF TEMPERATURE AND OTHER GASES PRESENT

One may note that the pressure which the water vapor contributes to the total atmospheric pressure is small at ordinary temperatures. For example, the vapor pressure at 75 F (degrees Fahrenheit) and 50 per cent relative humidity is only a little over 0.2 lb per sq in. From a consideration of Dalton's law of partial pressures, the vapor pressure is the same whether other gases are present or not. It is, therefore, independent of changes in atmospheric pressure, providing the absolute humidity remains the same.

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Author: Research assistant, agricultural engineering section Iowa Agricultural Experiment Station. Mem. A.S.A.E.

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*Numbers in parenthesis indicate references cited at the end of this paper.

A very useful fundamental concept in dealing with moisture transfer problems is that the absolute vapor pressure above the dew point is independent of temperature changes. The only way then that the vapor pressure may be changed is by some process of either humidification or dehumidification of the surrounding atmosphere. To illustrate the principle, let us suppose that air within a room is heated above the temperature of the air outside of the room, assuming that before heating the temperatures and vapor pressures of the air inside and out were the same. The water vapor as well as the gases in the air expand and exert a greater pressure, with the result that some of the vapor and gases leave the room until the partial pressures as well as the total pressure are the same as before. Although the relative humidity and even the density of the water vapor changed, the vapor pressure remained constant.

Vapor Pressure — Moisture Content Relations for Hygroscopic Materials. A hygroscopic material at a given moisture content and temperature exerts a definite vapor pressure. The temperature effect in this case is quite opposite to that with water vapor. These pressures are also small at ordinary temperatures. Although it is difficult to conceive of materials being able to exert vapor pressures, direct measurements of pressures which are possible only under evacuated conditions, have been made on certain materials such as soils (2). The vapor pressures may also be determined for materials on which such direct determinations have not been made, providing the relative humidity and equilibrium moisture contents are known. To show how this may be done let us take corn for example, the data for which Alberts (1) has reported to be as follows:

Relative Humidity (per cent)	Moisture Content (per cent)
10	7
20	8
30	9
40	10
50	11½
60	13
70	15
80	17
90	20

We note from this table that at a relative humidity of 70 per cent, the corn has an equilibrium moisture content of 15 per cent. By that we mean that the vapor pressure of the corn and the water vapor at 70 per cent saturation are the same, providing both are at the same temperature. This identity tells us then that the vapor-pressure curve for corn at 15 per cent moisture coincides with the 70 per cent vapor-pressure curve. This assumes that the moisture content under the same relative humidity is the same regardless of temperature. (However. observations on wood (12) and even acids (13) show that there is a gradual deviation from this condition. These deviations are such that the increase in vapor pressure with an increase in temperature is greater for these substances than the corresponding relative vapor pressure. Expressing it in another way, the equilibrium moisture content is less for a given

relative humidity at higher temperatures. For purposes of this discussion we shall disregard such deviations.)

Likewise, the vapor-pressure curves for the other moisture contents could also be drawn. We would have then a chart which would enable us to determine the vapor pressure of corn at any moisture content and temperature. It should be noted that there are not the proportionate increases in vapor pressures for equal increments of added moisture to corn at the higher moisture contents. As a matter of fact, as more moisture is added to corn, it would approach the saturation pressure of water vapor as a limit, regardless of the amount added.

In a similar manner, vapor-pressure charts or tables could be constructed for other hygroscopic materials for which equilibrium moisture-content data are available.

Moisture Transfer Problems. The transfer of moisture in the vapor form is distinctly a flow problem. The forces which tend to bring about flow are the vapor-pressure differences, and the forces opposing flow are the resistances which mediums offer to the flow of vapor through them.

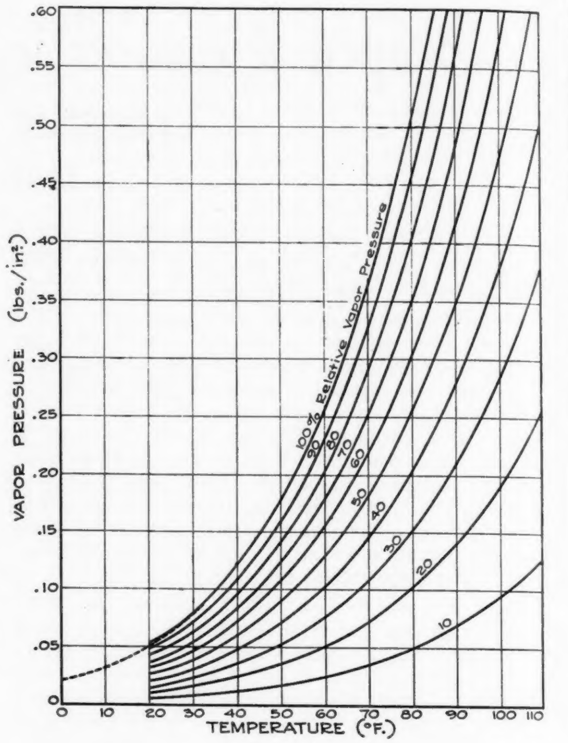
The flow of water vapor through mediums is analogous to the flow of heat, and is usually considered to be some kind of a diffusion process. In heat flow, energy flows from a region of higher temperatures to one of lower; in the flow of water vapor, moisture is transmitted from a region of higher vapor pressures to one of lower. The property which expresses the ability of materials to transfer heat is known as thermal conductivity; in the flow of vapor, the ability of materials to transmit water vapor is known as water-vapor permeability.

VAPOR TRANSFER DEPENDS ON PRESSURE DIFFERENCE AND RESISTANCE TO VAPOR FLOW

In heat flow we are familiar with Newton's law of cooling, which may be stated as follows: the rate of cooling of a heated object is proportional to the temperature difference. Might we not expect a similar law to exist in moisture transfer, namely, that the rate of drying is proportional to the vapor-pressure difference?

In dealing with moisture transfer problems, we are concerned then with the differences in vapor pressures and the resistance of the material under consideration to the flow of water vapor. From the above considerations of the chart and the vapor-pressure relationships of the material in question, we can easily see how vapor-pressure differences may be determined.

Water Vapor Permeability Measurements. Numerous determinations have been made of such materials as paint films, wrapping papers, and packaging materials on the permeability to water vapor (5, 7). The methods employed, the units of permeability, and the factors entering into such measurements have been reviewed by Carson (3) of the U. S. Bureau of Standards. In most measurements the material or specimen is subjected to a constant vapor-pressure difference, and the amount of water vapor passing through is in most methods determined by weighing. A convenient and common method is to seal the specimen to the top of a shallow tray or dish which contains water or some other reagent to give a desired relative vapor pressure. The dish with its contents is placed either in a conditioned cabinet or room and weighed at intervals to determine the rate at which the water vapor is passing through the specimen. With the area of the specimen, rate of loss, and vapor-pressure difference known, the water-vapor permeability is expressed in weight of vapor permeated per unit of time per unit of area per unit of vapor-pressure difference. The reciprocal of permeability may be termed the resistance to the flow of vapor.



Although the method of test is fairly simple, the amount of vapor which permeates the specimen depends also on a number of other factors (4), namely, the relative humidity at each face of the specimen, the actual vapor pressure at each face of the specimen, which may give a vapor pressure across the specimen less than the total vapor-pressure difference, and intervening dead air spaces between the specimen and the reagent. Results of permeability tests on hygroscopic materials show that the amount of water vapor transmitted varies directly with the vapor-pressure difference, when the relative humidity does not exceed 75 per cent. Above 75 per cent, the amount transmitted per unit vapor pressure difference is usually greater.

PRACTICAL FARM APPLICATIONS OF VAPOR PRESSURE LAWS

Condensation of Moisture Within Walls. Closely associated with water-vapor permeability is the problem of moisture accumulation or condensation within walls of houses during cold weather, or in walls of refrigerator rooms. In most houses some humidification is provided, especially in cold seasons, either artifically or through natural means. When this is done, the vapor pressure is actually higher on the inside than on the outside, although the atmospheric pressure on both sides may be the same. As an example, if the outside temperature is 20 F and 100 per cent relative humidity, one will find from the chart that the vapor pressure is 0.05 lb per sq in, and if the inside is at 75 F and 35 per cent relative humidity, the vapor pressure is noted to be 0.15 lb per sq in, giving a difference in vapor pressure on the two sides of the wall of 0.10 lb per sq in, or over 14 lb per sq ft. This appears to be an insignificant pressure, but water-vapor permeability tests on plasters, building boards, and papers show that considerable moisture may flow through under such differences in pressures.

Whenever walls are subjected to conditions similar to those indicated above, and the walls are permeable to water vapor, a flow of vapor from the room toward colder regions in the wall takes place. If the inside wall is permeable enough so that the drop in vapor pressure in flowing across it is not large, the relative vapor pressure may reach 100 per cent because of the lower temperatures which are encountered as the vapor flows toward the outside. If that is the case, condensation of water vapor within the wall may result.

Natural and Artificial Drying. The force tending to rid a material of its moisture is simply the difference between the vapor pressure of the material and that of the surrounding water vapor. The rapidity with which the material will lose its moisture will depend primarily on the magnitude of the difference in pressures and the permeability of the material itself to the flow of water vapor, some of which has to permeate from inner regions through outer layers.

It is apparent from some of the above discussion that, in order to obtain large vapor-pressure differences, the material to be dried must be heated to increase its vapor pressure and that the pressure of the surrounding water vapor be kept low, if rapid drying is to be accomplished.

In applying this concept to artificial drying with forced heated air, as in grain drying, the essential purpose which the heated air accomplishes in passing through the grain is the heating of the grain to increase its vapor pressure. This purpose is primary and, when accomplished, satisfies a necessary condition for rapid drying. The air in passing through the grain accomplishes another important function of removing the moisture which the grain gives off and prevents a "back pressure" being produced by the moisture given off. Although the relative vapor pressure is decreased by the heating of the air, the absolute pressure remains the same, providing no moisture is added nor removed. Although heated air is considered "drier" in the sense that more moisture can exist in a given space at the higher temperature, the vapor pressure is unaltered by heating. In other words, the pressure differences in drying with heated air are obtained by an increase in vapor pressure of the grain and not by a decrease in that of the surrounding water vapor, and the drying is accomplished because the grain is heated, not because the air is heated.

There are several ways in which the pressure of the surrounding water vapor may be reduced. Absorbents such as calcium chloride and silica gel, which have low vapor pressures even at high moisture contents, have been employed in grain drying (6). Vacuum driers maintain reduced vapor pressures by exhausting the vapor. Low pressures can also be maintained by cold surfaces, which is apparent from an inspection of the accompanying chart.

In natural drying the material is, for the most part, at the same temperature as that of the surrounding air, and the vapor-pressure differences are relatively small at ordinary temperatures. The differences become still less with lower temperatures, so that during the winter season the drying rates are very low, as is known in the case of ear corn in storage.

Even in nature's way, the principles which make for rapid drying are employed. Green hay on a bright day heated by the radiant heat from the sun dries rapidly due to its increased vapor pressure over that of the surrounding air.

MOISTURE TRANSFER IN SEALED REFRIGERATOR INSULATION

Moisture Redistribution. An interesting phenomenon is that of redistribution of hygroscopic moisture, which is often referred to as migration of moisture. McPherson (9, 10) has observed this phenomenon in the insulation in walls of household refrigerators. He reports that air-dry insulation of about 6 per cent moisture placed in refrigerator walls, which were tightly sealed, exhibited after several months a low moisture content next to the warm wall and a much higher moisture content next to the cold wall. In the bottom of the refrigerator the insulation actually contained liquid water. This phenomenon may readily be explained on the basis of the vapor-pressure concept. Due to the fact that the walls are subjected to a temperature difference, the various layers of insulation between the warm and cold wall are all at different temperatures. Since the insulation next to the warm side will have a higher vapor pressure than that next to the cold side, a transfer of moisture is imperative. The moisture will eventually be so distributed that the vapor pressure is the same in all parts of the refrigerator walls. Since the vapor pressure was lowest at the bottom of the refrigerator due to the lower temperature, the moisture accumulation was greatest at that point.

This phenomenon occurs also in the storage of grain. Any temperature differences occurring within the mass of the grain will produce a migration of moisture, because the vapor-pressure equilibrium which may have existed previously has been disturbed. These temperature differences may result from outside temperature fluctuations, but frequently they may result from slight heating of the grain in the center of the bin. This condition, in combination with a cool floor as a result of its contact with the ground, will likely result in a transfer of moisture from the warm to the cool grain. Although the transfer need not result in condensation, the increased moisture content and higher humidities may be sufficient to cause spoilage.

Numerous other moisture-transfer problems may satisfactorily be analyzed through the use of the vapor-pressure concept. It offers a direct and meaningful approach to the study of these problems. With appropriate data, problems dealing with moisture transfer can be put on a more calculative basis, similar to that of heat transfer.

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The Physical and Financial Aspects of Public Drainage Enterprises

By Lewis A. Jones

IN DISCUSSING the factors influencing the physical and financial aspects of public drainage enterprises, it seems desirable to call attention to the fact that a large majority of such enterprises in the country have proven successful and have resulted in the development of some of our most prosperous agricultural areas.

Regions such as northwestern Ohio, northern Indiana, central Illinois and north central Iowa were originally composed largely of swamps or sloughs, with chills and fever prevalent among the inhabitants. Drainage has changed these conditions to such an extent that these same areas now rank among the most valuable agricultural regions in the world. In these localities it is common to find single counties with from 1000 to 3000 miles of public ditches and drains. Most people do not realize that the maintenance of these drainage improvements is essential—that if such improvements are not maintained the land would, in a comparatively short time, revert to its original condition with the accompanying dangers to the health of the inhabitants. The lack of appreciation of the importance of maintenance has been especially prevalent during the past few years in which drought conditions have been widespread, and have tended to make landowners forget what happens during periods of normal or excessive precipitation. This, coupled with reduced farm income, has resulted in neglect of maintenance that will, unless corrected, result in serious losses when weather conditions become more normal. In most of these regions there are no outstanding bonds or obligations against the enterprises, and in most instances the landowners can well afford to pay the cost of necessary maintenance work. The primary difficulty is the lack of suitable provision for maintenance in the laws under which the districts are organized. Amendments making such provision are needed in the laws of most states.

A recent study indicates that, outside of the Florida Everglades and northern Minnesota, less than 2 per cent of the land in organized drainage enterprises has been abandoned. However, this does not mean that drainage districts in financial difficulties are so limited. During and immediately following the World War every effort was made to expand the agricultural production of the country. Land speculation was rampant and many drainage districts were organized in areas where the market value for uncleared cut over land was exhorbitant and where the cost of drainage improvements was excessive. Many such districts are in financial difficulties. While poor judgment was displayed in organizing many of these enterprises, it is not believed that those responsible should be criticised any more severely than the people responsible for the overexpansion of many industrial and commercial lines of business, or than the farmers who paid \$300 to \$500 per acre for farm land, only to be caught in the mire of financial difficulties later on when prices for farm products returned to a more normal level.

In some drainage districts difficulties that have developed have been due primarily to poor engineering design, but in many instances they have been the result of overcapitalization connected with a protracted period of low prices for all farm products. For a few years money brought into the districts from the outside by land speculators and in the form of farm mortgages, together with the current income from the land, enabled the districts to meet their obligations, but such outside funds are no longer available and action is now necessary to refinance on a basis that can be carried by the districts from income produced by the land itself. Holders of bonds must expect to accept the loss necessary to refinance on such a basis.

Plans for refinancing drainage enterprises can be accomplished only through the cooperation of all interested parties, and, to be successful, must be acceptable to both the bondholders and landowners. In many instances attempts to refinance certain districts have been made, but have been unsuccessful chiefly because of the failure to recognize the fact that any plan of settlement must be based upon the ability of the land to pay. It must be remembered that, in the absence of speculation, the landowners in the district can pay no more for drainage or other improvements than they can get from the land. Blood cannot be drawn from a turnip, and when funds are spent up to the earning capacity of the land, nothing remains but the principal of the investment. In any plan of settlement it is of vital importance also that adequate provision be made for maintaining the drainage improvements, in order that crops may be successfully grown and the income of the land maintained. The settlement of delinquent taxes is a matter of compromise between landowners and bondholders, but must be of such character as will not endanger future payments.

The methods followed in assessing benefits in drainage enterprises that have been developed under existing laws are, in my opinion, unsatisfactory, and have been responsible for some of the financial difficulties that have developed in connection with drainage work. It is usual to base the benefit assessments almost entirely upon the physical change in drainage conditions resulting from the work, with little or no attention being given to the resulting change in earning power. The benefit resulting to the owner in the form of increased earning power is much greater from the complete drainage of a piece of fertile land ready for the plow, than is that resulting from the complete drainage of an equal area of cut over timbered land with poor soil, although both areas require the same amount of drainage. After drainage, the fertile piece can be immediately put into cultivation without additional expense and will yield good crops. The cut over land must be cleared before it can be cultivated, and even after clearing it will never produce good crops. Yet, under existing practices, equal benefit assessments would be levied against both areas, provided they were equally well located. Equitable benefit assessments should take into *(Continued on page 252)*

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1, 1937.

Author: Chief, division of drainage, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Fellow A.S.A.E.

Results of Tests of a Rubber Roller Seed Bean Thresher

By Roy Bainer and J. S. Winters

DURING 1937 the experimental rubber roller seed bean thresher (Fig. 1) developed at the University of California and described in AGRICULTURAL ENGINEERING for May 1937, was tried in the more important bean-growing sections of California. The varieties threshed included small limas of the Wilbur and Hopi varieties; large limas of the Fordhook, Pacific, Flynn, and Burpee Improved varieties; small beans of the Red Kidney, Missouri Wonder, French Horticultural, Pinto and Blackeye varieties; garden peas, cow peas, and Dolochos (Fig. 2).

The principle of the machine appeared to have merit. A satisfactory thresh was obtained in practically all of the baby limas and other small beans encountered in the interior valleys. However, in the large lima bean section along the coast, where weather conditions make threshing much more difficult than in the interior, the thresher did not have enough rolls to take out all of the beans in one time through the machine.

Authors: Respectively, associate professor of agricultural engineering (Mem. A.S.A.E.), and associate agricultural engineer in the experiment station, University of California.

When threshing Fordhooks (large seed limas grown along the coast) under rather ideal conditions, 95 per cent of the beans were removed from the pods in one time through the machine. When the straw was run through a second time, an additional 4.7 per cent was taken out. This gave a 99.7 per cent thresh for two times through the machine. However, a 98.3 per cent thresh was obtained in the same beans, in one trip through the machine, when the straw was inverted between rolls, indicating that more agitation between rolls was necessary. In Burpee Improved, a thresh of 91.7 per cent and 99.5 per cent, respectively, was obtained for one and two times through the machine.

The machine showed promise in that it was able to thresh the large limas grown on the coast, even though two times through the machine were necessary. The general practice in this area is to rethresh all of the straw piles where standard three-cylinder, peg-tooth machines are used. It would be practical to add two or three more sets of rolls and do the threshing in one time through the machine. This would also make possible threshing from the windrow. The general practice in this area, at present, is to pile the

TABLE 1. SUMMARY OF 1937 TESTS ON EXPERIMENTAL SEED BEAN THRESHER

Variety	Moisture, per cent	Threshed (per cent) 1 time	2 times	Visible damage, per cent	Internal damage, per cent	Total damage, per cent	Remarks
Baby limas (Wilbur)	13.2	99.1		0.0	0.5	0.5	
Pinto	9.6	99.5		Trace	1.0	1.0	
Blackeye	8.6	97.5		0.75	2.97	3.72	
Baby limas (Hopi)	10.6	99.1		1.08	3.58	4.66	Average of eight fields
Red Kidney	13.0	98.8		Trace	0.0	Trace	
Missouri Wonder	14.6	84.2	99.4	Trace	0.0	Trace	Very poor threshing conditions
French Horticultural	15.6	86.4	99.8	8.4	2.74	11.14	ditto
Large limas (Fordhook)	16.4	76.0	98.0	1.17	0.98	2.15	ditto
Large limas (Fordhooks)	14.6	95.0	99.7	Trace	0.0	Trace	
Large limas (Fordhooks)	14.6	98.3		Trace	0.0	Trace	Straw turned over between rolls
Large limas (Burpee Improved)	13.7	91.7	99.5	0.42	0.49	0.91	
Large limas (Pacific)	17.7		91.9	0.6	0.0	0.6	Adjacent to ocean. Vines not dry.
Garden peas (Alderman)	11.0	99.9		0.0	0.0	0.0	
Cow peas (Iron)	8.8	97.1		Trace	3.5	3.5	
Dolochos		88.0		0.0	0.0	0.0	

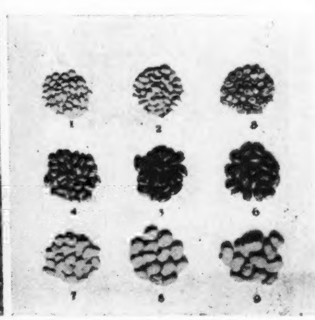


FIG. 1 (EXTREME LEFT) THE EXPERIMENTAL RUBBER ROLLER THRESHER WORKING IN BABY LIMA BEANS. FIG. 2 (LEFT) A REPRESENTATIVE SAMPLE OF BEANS AND PEAS THRESHED WITH THE EXPERIMENTAL THRESHER: (1) DOLOCHOS, (2) BLACKEYE, (3) GARDEN PEA, (4) PINTO, (5) RED KIDNEY, (6) FRENCH HORTICULTURAL, (7) BABY LIMA (HOPI), (8) LARGE LIMA (FORDHOOK), (9) LARGE LIMA (PACIFIC)

beans in small shocks, and then thresh them in stationary machines.

A summary of the field trials in beans and peas is shown in Table 1. The visible damage in eight different lots of baby limas (Hopi) varied from 0.55 per cent to 1.83 per cent, with an average of 1.08 per cent; while the internal damage, as shown by germination tests, varied from 1.98 per cent to 6.94 per cent, with an average of 3.58 per cent. The average of the total damage for the eight lots was 4.66 per cent.

The total damage to large limas varied from 0.6 per cent to 2.15 per cent. Samples of large limas (Fordhooks and Burpee Improved) taken from the machine by farmers and sent to the state seed laboratory, gave a germination of 97 per cent and 98 per cent, respectively. The total damage to several lots of large limas threshed by commercial machines, in areas where tests were run, varied from 6.7 per cent to 35.4 per cent.

Trials with red kidney beans gave only a trace of damage, while beans from the same field, threshed with a commercial machine, showed a total damage of 19.7 per cent.

The total damage to a lot of French Horticultural beans, supplied by one of the seed companies, showed 11.14 per cent damage. The greater part of this damage (8.4 per cent) was visible. The seed company reported that this variety was so fragile that hand threshing was always practical.

The worst job of threshing found in baby limas came from a single-cylinder commercial machine. The total damage was 61.8 per cent, which was divided equally among visible and internal injury.

When the project on seed-bean threshing was started, the single aim was to develop machinery that would thresh lima beans for seed purposes without producing the damage caused by the standard threshers. Trials in other varieties of beans have shown a wider usefulness for this machine. Efforts in this direction have been well received by both farmers and seedsmen. Indications at the present time are that two or three machines, employing rubber rolls, will be built before the next harvest season. One bean thresher company, located on the Pacific Coast, has already contracted with the Red Kidney bean growers of the Marysville area for one of these machines for the 1938 harvest. Others will no doubt follow.

Since beans threshed with this thresher show practically no visible damage, and due to the fact that the power consumption is so much lower than that required for the regular bean thresher, there is a possibility that this principle may be adapted, in part at least, to the standard bean threshers for use in commercial threshing.

The Physical and Financial Aspects of Public Drainage Enterprises

(Continued from page 250)

consideration soil fertility, cost of development, and increased earning power, as well as the physical change in drainage conditions.

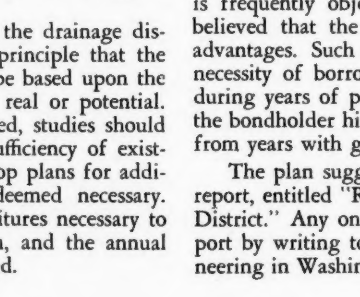
In rehabilitating existing enterprises, the drainage districts and bondholders should agree in principle that the payment of drainage assessments should be based upon the ability of the land to pay from income, real or potential. Before plans for refinancing are developed, studies should be made to determine the engineering sufficiency of existing drainage improvements, and to develop plans for additional improvements, should they be deemed necessary. Estimates should be made of the expenditures necessary to put the improvements in good condition, and the annual cost of maintenance should be determined.

The land of the district should be classified in accordance with its ability to pay taxes. This ability depends upon the natural fertility, state of development, location, and physical condition.

Studies should be made of past crop yields and farm prices, in order to determine the earning capacity of the various classes of land. These figures can then be used in levying drainage taxes under the plan of rehabilitation. Sufficient assessments should be levied against unimproved land to make the owner desirous of developing it so as to obtain income with which to pay taxes, and yet not high enough to convince him that it would be more profitable to abandon the land rather than pay taxes until he can develop it.

Arrangements should be made to base the tax levies each year upon crop yields and prices for that year. This will result in fluctuations in the amount available from taxes, which fact is frequently objectionable to the bondholders, but it is believed that the resulting advantages outweigh the disadvantages. Such a plan protects the landowner against the necessity of borrowing money or failing to pay his taxes during years of poor crops or low prices; and obtains for the bondholder his share of the increased earnings resulting from years with good crops and high prices.

The plan suggested has been worked out in detail in a report, entitled "Rehabilitation of the Little River Drainage District." Any one interested can obtain a copy of this report by writing to the U. S. Bureau of Agricultural Engineering in Washington.



SUMMARY

1 In all drainage enterprises, including those in sound financial condition, as well as those in financial difficulties, the maintenance of improvements is essential if full benefit is to be received from the monies expended. Such work must be done annually, not periodically, if the earning capacity of the land is to be maintained.

2 In a majority of the states, amendments to existing laws, providing for maintenance work, are needed.

3 In planning for the rehabilitation of drainage enterprises in financial difficulties, the plan of refinancing should be based upon the ability of the land to pay, and should include provisions for the rehabilitation and annual maintenance of the drainage improvements.

Agricultural Engineers in Cooperative Activities

By Arnold P. Yerkes

President, American Society of Agricultural Engineers

EVERY citizen of a civilized country owes a debt of gratitude to the achievements of the chemists, and the great industry they have built. The chemical industry has done magnificent work in producing abundantly the chemical products needed for our comfort, convenience, safety, and health—for a longer and happier life.

Yet it may be said that the works of the engineer are equally omnipresent and equally as valuable to mankind as are those of the chemist. Chemistry and engineering might be termed supplemental sciences—each depends to a very large extent upon the other for fullest functioning.

It seems quite appropriate, therefore, that in your discussions of ways and means for the chemical industry to extend still further its services to our nation, by creating new uses and markets for farm products, consideration be given to possible ways in which the engineer may cooperate with the chemists to attain a desired goal.

I have been asked to discuss the progress of that field of engineering which is most closely allied to the work of the National Farm Chemurgic Council, that is, agricultural engineering, which has been defined as "the science of utilizing the materials and forces of nature for the benefit of agriculture."

The origin of engineering science is lost in antiquity, as is also the origin of several other arts and sciences. But the surviving aqueducts and roads of the Romans, the irrigation canals and terraces of the Incas, and numerous other engineering works of ancient civilizations attest the fact that the engineer not only existed in early times, but builded well and with marvelous permanence.

So long as the human race depended upon the power developed by the muscles of men and animals, the progress of engineering, as well as of the human race itself, was extremely slow. Engineering has made its greatest progress and performed its greatest services in the comparatively short period since Watt and his colleagues developed the steam engine. The rate of this progress was of course greatly accelerated by the invention of the internal-combustion engine and the mastery of electricity, both of which were participated in by numerous engineers to whom we owe a debt of gratitude beyond calculation.

It may be news to some that efforts to adapt power from steam and internal-combustion engines to farming operations were largely contemporary with the introduction of such power into other industries. As early as 1858, steam power turned furrows in the soil of the United States, and there are records of gas tractors in this country in the late eighties, when the internal-combustion engine was making its debut as a source of industrial power and as a substitute for the horse in the horse-and-buggy combination.

Today the men who made those early efforts to adapt mechanical power to farming operations, as well as those who had even earlier developed the reaper, the binder, the threshing machine, the combine, the grain drill, and numerous other machines, which lightened the labors of farmers and freed the human race from the former well-founded fears of famine, would be classed as agricultural engineers. In those days, however, agricultural engineering as a special field of engineering science was unknown.

It was not until 1896 that this classification was established. And it was at the agricultural school of the state in which this conference is being held, in its capitol city of Lincoln, that the first course in agricultural engineering was offered to the youths of this state, under the direction of the late O. V. P. Stout.

A graduate of the University of Nebraska, Jay Brownlee Davidson, was one of the first instructors in this course, and in 1905 he was called to the Iowa State College to become head of the first department of agricultural engineering, a position he has held until this day with only a brief interim, during which he was head of a similar department in the University of California.

The work in agricultural engineering inaugurated by the University of Nebraska had shown such excellent results, attracted so much interest, and seemed to offer such great promise, that similar courses were promptly instituted at numerous other state colleges, although not always under the same title. As a result of this development, a group of men engaged in teaching these courses, and a few others interested in the work—about sixteen in all—held a meeting at the University of Wisconsin in December 1907 to discuss their mutual problems. Before these men adjourned their meeting, they had founded the American Society of Agricultural Engineers.

The fact that the Society has grown steadily during the past thirty-one years, until today it numbers over a thousand members, is perhaps the best evidence which could be offered to prove that agricultural engineering has really made remarkable progress within the memory of most of those present here.

It would take too long to attempt to explain in detail the many kinds of work in which agricultural engineers are engaged today in research, extension, and industrial pursuits, in addition to educating an ever-increasing number of young men in the science of agricultural engineering. Besides covering a broad field that is purely engineering, they are also cooperating at many points with practically every other branch of agricultural science.

The scope of the work which has been carried on by the agricultural engineer might be summarized briefly as follows: He has given to American farmers highly efficient tractors and full lines of tillage, seeding, harvesting, dusting, spraying machines, etc., for use with them. He has given the farm family a better, more convenient, and more comfortable home. He has provided barns, stables, poultry houses, pig pens, corn cribs, silos, and other farm structures which are far more suitable for the purposes for which they are intended than the farmers of former generations ever dreamed of possessing. He has brought the convenience, comfort, and economy of electric current to the farm home and other buildings and has made electricity perform many new services, such as insect control, soil

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An address before the Fourth Annual Conference of Agriculture, Science, and Industry, sponsored by the National Farm Chemurgic Council, at Omaha, Neb., April 25-27, 1938.

Author: Editor, "Tractor Farming," International Harvester Co. Mem. A.S.A.E.

heating and sterilization, crop preservation, chicken and pig brooding, etc., in addition to the common services of lighting, water pumping, ironing, washing, and refrigeration.

He has developed various methods of controlling the loss of soil from wind and water erosion, some of which are applicable to almost any land which can be farmed. He has made it practicable and profitable to retain more of the rainfall when this is desirable; to irrigate dry areas and to drain wet ones.

That is a very hasty and inadequate sketch of the work the agricultural engineer has been carrying on. A much more complete picture could be given by merely summarizing the latest annual report of the chief of the Bureau of Agricultural Engineering of the U. S. Department of Agriculture.

The temptation is strong to attempt right here to point out some of the many important effects which the work of the agricultural engineer has had upon the nation's economic life. It would not be difficult to show that the more efficient farm equipment developed by the agricultural engineer has made it possible for a smaller percentage of our population to produce the foods and fibers needed by our entire population, and thus release workers for the development of other industries, arts, sciences, and professions. It would be equally easy to show that the net result from the introduction of these products of engineering science has been the creation of greater employment in the nation as a whole, and not an increase in unemployment as some people claim.

But before such a group as this, it should not be necessary to explain the benefits which result from reducing the number of workers required for farm production and the building up of urban industries for the transportation, storage, processing, and retailing of farm products such as we have in our meat packing, dairy, cereal, and other industries whose very existence depends upon the use of modern methods and equipment on the part of farmers.

What you are more interested in, it seems safe to assume, is a listing of activities which agricultural engineers are engaged in, or can properly undertake, having close relation to the work of the National Farm Chemurgic Council.

It would seem that in practically every activity in which you are now engaged, or which has been proposed for your consideration, the agricultural engineer can be of considerable assistance.

It is your aim to find new and profitable uses for present farm crops, and introduce or popularize crops not now commonly grown in this country. This will doubtless involve some new problems of planting, cultivating, harvesting, storing, processing, and handling. In solving these problems, the wide experience of the agricultural engineer in dealing with more or less similar problems certainly offers your best hope of a prompt and satisfactory solution.

It is not meant to convey the impression that the agricultural engineers have solved all their own problems and are now standing with folded arms waiting for someone to offer them new worlds to conquer. The need for research in agricultural engineering is still tremendous, in order to further improve the equipment and technique for numerous operations. But when you have the problem, for example, of harvesting a new crop, surely the men who have had a hand in the development of our present-day combines, potato harvesters, corn pickers, beet pullers, ensilage harvesters, and so forth, should be the most competent group to whom you could turn for help.

Or, again, you may wish to store or perhaps dry some crop for a new method of processing. The agricultural engineers have done extensive research work in the most efficient methods of storing fruits, vegetables, grains, and forage crops. They have learned much about refrigerating, about drying, and about humidifying many farm crops. They should be, and I believe are, in an excellent position to cooperate with you in problems of this kind, just as they have cooperated with others in the past.

Experience would seem to indicate that most of the problems connected with agricultural production are such that they can be solved best by cooperation between two or more branches of science. For instance, take the subject of soil fertility. At first thought, this might seem like a problem for the soil chemists alone. But the soil chemists want to practice green manuring under certain conditions. This involves preparing a seedbed and planting a crop. These operations require power and suitable equipment—a job for the engineer. Then the crop must be turned under or worked into the soil according to rather definite specifications. Again, power and suitable implements are required, and the agricultural engineer has been glad to cooperate in accomplishing these things in just the way the soil chemists specified.

For some crops and conditions, the soil chemist recommends commercial fertilizer, which he wants placed at a specified depth in carefully measured quantities and at a definite distance from the seed. The agricultural engineer cooperated and produced machines to meet the specifications with a high degree of mechanical accuracy.

The entomologists and plant pathologists learned by their research that certain chemicals would control insect pests and plant diseases if applied in a certain manner and at just the right time. In some cases they wanted the chemicals applied as a liquid and in others as a powder. Again the agricultural engineer cooperated in solving the problem. He developed the power plant, the pump, the atomizing nozzles, and the blowers. Spraying and dusting are today done with an effectiveness and speed several times as great as was the case a few years ago—through cooperation.

Some of you probably recall what happened when the European corn borer was causing such havoc in the cornfields of Ohio, Michigan, and Indiana. The entomologists tried all the various weapons they had developed in their endless battle against bugs. Poisons, contact sprays, and parasites failed to stop the invader. But the entomologists discovered that plowing the infested fields so as to cover every bit of vegetation would give effective control. But such plowing with existing equipment was almost impossible. Again the agricultural engineer cooperated and produced special plows and attachments which made such work easy and practicable.

Within the past few years methods of converting grasses and legumes into excellent silage have been developed. These involve the adding of an acid or of sugar (usually in the form of molasses) to the green material as it is placed in the silo. The development of these processes was entirely the work of chemists. However, before it was practicable for farmers to utilize these new methods. It was necessary to modify some of the machines commonly used in handling hay crops and to devise some entirely new equipment.

These were jobs for the agricultural engineer, and he has promptly responded by providing stronger side-delivery rakes and hay loaders suitable for handling the green crops which are about three times as heavy as the cured hay these machines were originally intended to handle. He has also devised machines for loading the green material directly onto a wagon from the (Continued on page 257)

Fuel Experience from Nebraska Tests

By Carlton L. Zink

THE NEBRASKA Tractor Test Law became effective July 15, 1919. It was enacted to encourage the manufacture and sale of improved types of tractors and to contribute to a more successful use of the tractor for farming.

It was thought that the best method of accomplishing these objects would be to require a tractor of each model sold in the state to be tested at the state university and to have the results of these tests made public. Briefly, the provisions of the law are as follows:

1 That a stock tractor of each model sold in the state shall be tested and passed upon by a board of three engineers under state university management.

2 That each company, dealer, or individual offering a tractor for sale in Nebraska shall have a permit issued by the state railway commission. The permit for any model of tractor will be issued after a stock tractor of that model has been tested at the university and the performance of the tractor compared with the claims made for it by the manufacturer.

3 That a service station with a full supply of replacement parts for each model of tractor shall be maintained within the confines of the state and within reasonable shipping distance of customers.

One of the problems encountered by the group of three engineers, known as the Tractor Test Board, was the selection of a proper fuel on which these tests should be made. It was decided that where tractors were advertised to operate on more than one fuel, such as gasoline or kerosene, the lower grade fuel, or kerosene, be used. No premium fuels were used then, nor are any at the present time, except in those cases where the manufacturer states that they are essential to the satisfactory operation of the tractor.

Because of the desire to reduce the test "variable" to a minimum, there has been no shopping around for test fuel where it was possible to avoid it. Gasoline and kerosene marketed by the Standard Oil Company of Nebraska and produced by the Standard Oil Company of Indiana were selected for the tests because of their general distribution over the state and the uniformity of their quality. Fig. 1 shows distillation curves for fuel used in 1920 and 1921.

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., November 30, 1937.

Author: Engineer in charge of Nebraska tractor tests, department of agricultural engineering, University of Nebraska. Mem. A.S.A.E.

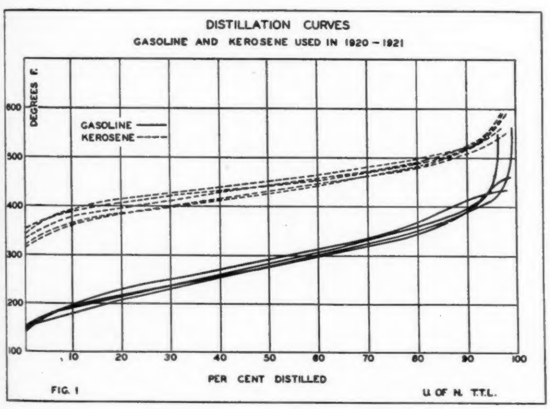

FIG. 1

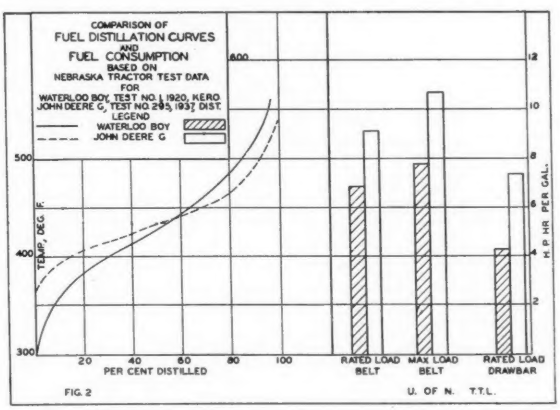

FIG. 2

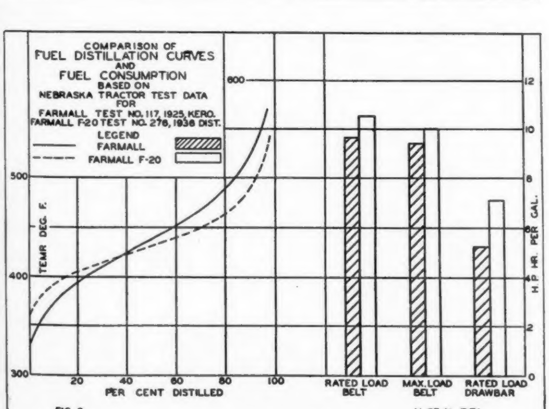

FIG. 3

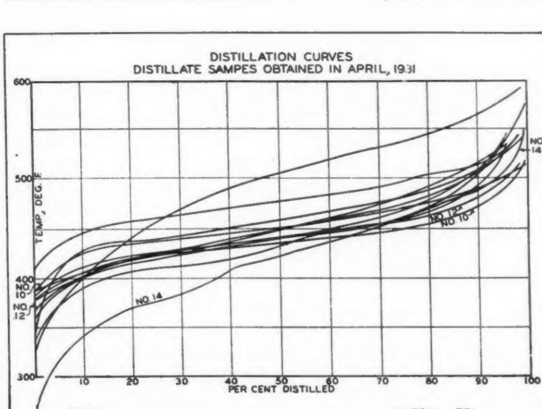

FIG. 4

These values do not include every fuel test made in those years but are, I believe, representative.

Test No. 1 was made on the Waterloo Boy tractor, and it is interesting to me that the last test made in our current season was on the John Deere G, test No. 295. From data appearing in Fig. 2, one may make a comparison of the fuel used and the performance obtained from these two tractors, one tested at the beginning and the other at the end of an 18-yr period. While I shall not attempt to analyze these figures, I should like to point out that the improvement of the late model over the early one is much more noticeable on the drawbar than on the belt, due in the main, I presume, to improved traction and weight distribution, and to reduced transmission losses. Test No. 1 was made on kerosene and No. 295 on distillate.

In Fig. 3 is a similar comparison, made on the first Farmall and on the latest model, the current F-20. The improvement of the new over the old is not so noticeable in this instance, and probably should not be, considering that the first Farmall test was made in 1925. The whole tractor industry had learned new and better ways in the years from 1920 to 1925. In this case also the early test was made on kerosene and the late one on distillate.

The first tractors tested on distillate were two Hart-Parr models, in 1926. For those and all subsequent distillate tests, Standard Oil No. 1 furnace oil has been used. In the early years independent jobbers handled this fuel for the gravity type, domestic oil burners, but starting with 1935 it was available at the local Standard Oil bulk plant under the name of tractor fuel.

Comparative analyses showed that the tractor fuel was apparently the same fuel that we had been using as No. 1 furnace oil, and a letter was obtained from the local Standard Oil plant manager stating that the fuels were identical.

In 1931 we purchased some Standard No. 1 furnace oil from a local independent dealer, but through an error our tanks were filled with another fuel which they also handled. This fuel was very unsatisfactory, due, I believe, to an absence of unsaturated hydrocarbons which would effect its anti-knock qualities. While trying to find our way out of the fog, we obtained a number of samples of distillate from the surrounding territory. A rather complete analysis was made on all of them, and a number were checked in a tractor engine belted to the brake. Fig. 4 shows the distillation curves for several of these fuels. Fuel No. 12 was Standard No. 1 furnace oil, No. 10 was the very unsatisfactory fuel obtained through an error, and No. 14 was one of the first "hot" tractor fuels sold in this area.

A detailed comparative analysis of fuels No. 10 and No. 12 appears in Fig. 5. The distillation curves run very close to each other; there is 18 deg (Fahrenheit) difference in the initial boiling points and only 4 deg between the end points. The total recovery on No. 10 is 99.8 per cent and on No. 12 is 98.5 per cent. The color of No. 10 was water white, and of No. 12 light straw. The casual observer would have selected No. 10 as the better fuel. Maximum belt horsepower determinations were made on a low-grade-fuel-burning engine using these two fuels with gasoline checks. The maximum horsepower on No. 10 varied from 43.50 to 45.50, and there was a large amount of detonation. On No. 12 the horsepower developed ranged from 49.00 to 49.25 and there was very little detonation.

No information is available as to the octane value of

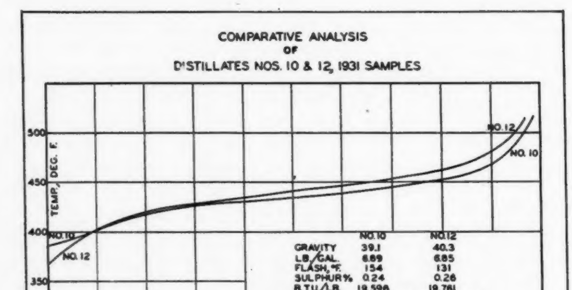

FIG. 5

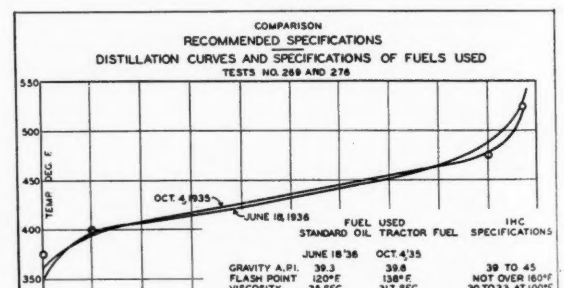

FIG. 7

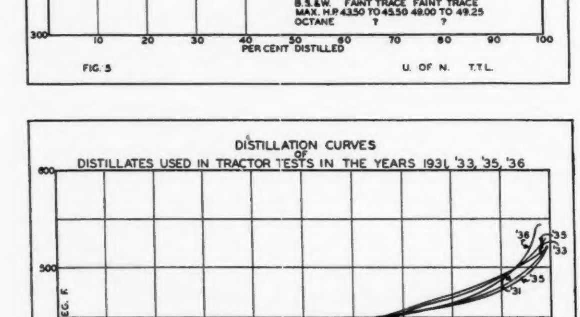

FIG. 6

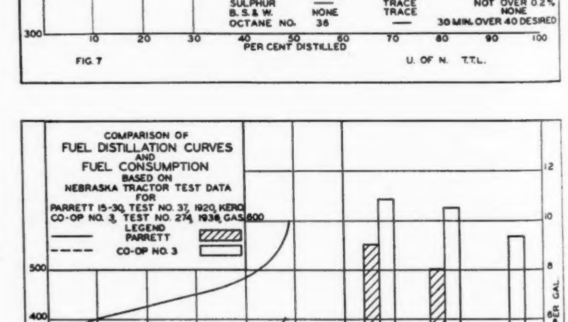

FIG. 8

DIESEL FUEL SPECIFICATIONS

	CATERPILLAR			I.H.C.
TEST NO.	208	218	256, 273	230, 246, 277
FLASH	———	———	MIN. 150° F.	MIN. 150° F. OR LEGAL MIN.
B S & W	0.5% – 0.5%	0.5%	0.05%	0.5%
VISCOSITY	800 MAX. 32 0 –40	MIN. 35 SEC. AT 100° F.	MIN. 35 SEC. AT 100° F.	MIN. 35 SEC. MAX. 100 SEC. AT 100° F.
CARB. RES.	———	———	0.25% MAX. BY WT.	1.0% BY WT.
ASH	———	———	0.01% MAX. BY WT.	———
POUR PT.	———	———	FLOW AT OP. TEMP.	LOWER THAN AIR TEMP.
CETENE	———	———	45 MIN. SUGGESTED	———
SULPHUR	1.5%	1.0%	2.0% BY WT.	1.5%
FREE ACID	———	TRACE	———	———
GRAVITY	———	———	———	MIN. 24 DEG.
10% DISTILLED	———	———	———	460° F. MAX.
95% DISTILLED	———	———	———	675° F. MAX.
END POINT	———	———	———	700° F. MAX.

FIG. 9 U. OF N. T.T.L.

these two fuels, but it is my opinion that No. 10 had a very low anti-knock value. I feel that this characteristic was responsible for the low horsepower and violent detonation on these tests.

Standard No. 1 furnace oil (No. 12) has been used in later years. Tests made at intervals show it to be of quite uniform quality. The distillation curves obtained from these tests have been plotted in Fig. 6. Samples have been sent to Waukesha Motor Company from time to time for octane determinations. The first sample sent in August 1935 had an octane value of 32. All other samples have been 36, except one in April of this year, which was 38.

The Oliver Farm Equipment Company have specified on two of their late distillate tests that the octane value be 36 or higher. In Fig. 7, two samples of distillates used in tests in 1935 and 1936 are compared with the fuel specifications accompanying the application for test of the McCormick-Deering models W-40 and F-20. You will notice that these two samples fit the I.H.C. specifications very nicely, except at the upper end, where one of the fuels is about 15 deg high at the 90 per cent and end point.

In the application for test of the I.H.C. 8-16, test No. 25 (1920), the only restriction on the use of distillate was that the gravity should be 39 deg Baume. The present specifications are much more inclusive, and the tractor user should purchase fuel that will meet them.

In Fig. 8 is a comparison, not between two similar tractors but between two machines for which one man has been responsible. The Parrett 15-30, test No. 37, was tested on kerosene in 1920. The Co-op No. 3 is unusual in some respects. No steel wheels are furnished; rubber tires are standard equipment; the engine is of the high-compression, truck-type that several engineers are considering quite seriously. The fuel economy established by this tractor on the rated load drawbar test is 9.37 dhp-hr per gal.

In 1932 the Caterpillar Tractor Company brought their first diesel-powered tractor to Lincoln for a test. It was necessary to find some fuel that would be suitable and the only local source of supply was fuel oil suitable for the power type domestic burners. The diesel fuel specifications were rather limited as may be seen by examining the column headed 208 in Fig. 9. When the next diesel came, the specifications under column 218 applied. A minimum viscosity figure is included and the allowable sulphur is decreased from 1.5 to 1 per cent. The application for test of the RD-7's and RD-8's and the RD-4 indicate that there are other important fuel characteristics. There is now a minimum flash point of 150 F. The allowable sediment and water are reduced from 0.5 to 0.05 per cent,

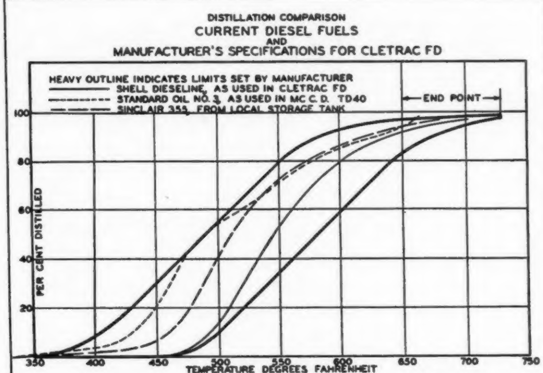

FIG. 10

indicating that *clean* fuel is evidently a very important factor. A limit has been set on the carbon residue and the ash; the pour point is designated and the ignition quality is given some attention. The allowable sulphur has been raised from 1 to 2 per cent.

When the Cletrac DD came for test, the source of fuel supply was again canvassed. Out of the nine samples obtained, only one would meet the Cletrac specifications (Fig. 10). This one was taken from a barrel of Shell Dieseline, shipped in by the Shell dealer for a contractor friend to try. The Shell dealer decided to stock Dieseline, and it has been used in tests 235, 241, 242, 253, 254, 255, 256, 257, 263, 277, 286, and 287. On test 285 both Sinclair 355 and Dieseline were available, and the manufacturer chose the Sinclair fuel. Fig. 10 also shows how the three diesel fuels which have been used most here fit into the fuel specifications set up by Cletrac.

The diesel fuel situation is infinitely better than it was back in 1931 and 1932, but one rule still applies, and that is the one advocated by Caterpillar: "Buy Clean Fuel, Keep It Clean."

Agricultural Engineers in Cooperative Activities

(Continued from page 254)

cutter-bar of the mower, as well as a machine to gather the green crop from a windrow, cut it ready for the silo, and load this cut material into a wagon.

Numerous other similar examples of such effective cooperation could be cited, but those mentioned should suffice to show that in many cases cooperation between agricultural engineers and those engaged in other agricultural sciences has brought about very satisfactory results. Hence, it seems quite probable that in some of the new problems with which the National Farm Chemurgic Council will be confronted in the future, the agricultural engineer may be able to render some worth-while assistance. At least he is quite sure to be ready and willing to do his part in helping with any such problem, and his record to date indicates that he has made sufficient progress in the past to warrant a reasonable degree of faith in his ability to deliver.

Please understand, however, that these remarks are merely the expression of an individual, and not of the American Society of Agricultural Engineers, nor of agricultural engineers as a group. I have no authority, nor has any other individual, to commit the Society to any program or activity. Yet from their past record there seems little doubt but that the agricultural engineers can be depended upon to lend their best efforts to any program designed to promote the common welfare.

A Proposed Method for Determining the Uniformity of Ground Feeds

By E. A. Silver

THE OUTSTANDING objection to the modulus system for determining the fineness of ground feeds, both from the engineering as well as the animal production standpoint, is that it gives no expression in the final solution to denote the uniformity of size of particles in a sample of ground feed. It is entirely possible to have the same modulus determination on two samples of feed, one of which would contain uniform sized particles, and the other irregular in size. For instance, the particles might be of such size that they would all remain on the No. 28 screen, which would give a modulus of 3.00. Then we might have another sample of various sized particles which would still have a modulus of fineness of 3.00, but distributed in proper amounts on each of the seven screens used in the determination. This feature is especially undesirable because it does not give any indication in regard to the amount of fine and coarse particles in the ground feed.

Therefore, the Committee on Feed Processing of the American Society of Agricultural Engineers has been cooperating with a committee of the American Society of Animal Production in an endeavor to find a supplement to the modulus system expressing the uniformity of size of particles in the ground feed. This work was started in 1937 by the chairman of the A.S.A.E. committee with the cooperation of Dr. R. W. Bethke of the Ohio Agricultural Experiment Station, who was then chairman of the Investigations Committee of the A.S.A.P.

Several different systems were suggested, and each given thorough consideration. It was the opinion of both committees that a simple system be devised which would express uniformity in an effective manner. It was further decided to leave the modulus system intact and to supplement an expression which would indicate uniformity. The expression which was finally adopted was a ratio of three figures showing the relationship to the amounts of coarse, medium, and fine particles in the ground feed. The total of these three figures equals ten (10) and which will vary from a 10:0:0 to a 0:0:10 ratio. Sixty-six combinations of figures can be used between those two extremes which is sufficient to express uniformity at any modulus determination. For example, modulus and uniformity determinations are expressed as follows: 3.00 — 1:9:1. From this expression it is seen that this is a fairly uniform sample, because there are nine parts of medium-sized particles and one part each of coarse and fine particles.

In the modulus system, seven screens are used: 3/8-mesh, 4-mesh, 8-mesh, 14-mesh, 28-mesh, 48-mesh, 100-mesh, and the pan. After the percentage of material remaining on each one of these screens was determined, it was decided to add the percentages on the screens above and on the No. 8 screen for the first figure; add the percentages on the Nos. 28 and 48 screens for the second figure of the ratio, and what passes through the No. 48 screen for the third figure.

After these totals have been attained, the next step is to divide each by ten in order to convert into one whole number. If the tenths are five or greater, they should be converted to the next whole number. Occasionally the total of these three figures will not equal ten; hence it is necessary to convert the highest tenth or hundredths to the next highest whole number. An example of Modulus of Fineness and Uniformity is as follows:

Modulus Determination		Uniformity Determination		
Screen mesh	Percentage on each screen	Adding percentages from modulus determination	Dividing each total by ten	Converting to a whole number
3/8	1.0 × 7 = 7.0			
4	2.5 × 6 = 15.0			
8	7.0 × 5 = 35.0	10.5	= 1.05 =	1
14	24.0 × 4 = 96.0			
28	35.5 × 3 = 106.5	59.5	= 5.95 =	6
48	22.5 × 2 = 45.0			
100	7.5 × 1 = 7.5			
Pan	0.0 × 0 = 0.0	30.0	= 3.00 =	3
	Total = 312.0			

$$\text{Modulus} = \frac{312}{100} = 3.12 \qquad \text{Uniformity } 1:6:3$$

Final Determination = 3.12 — 1:6:3

The following two examples are given to show the value of having an expression for uniformity when two samples have the same modulus determination but varying to a large degree in the size of particles.

Screen, mesh	Example 1 Percentage	Example 2 Percentage
3/8	0.0 × 7 = 0.0	0.0 × 7 = 0.0
4	0.1 × 6 = 0.6	0.0 × 6 = 0.0
8	4.7 × 5 = 23.5	0.0 × 5 = 0.0
14	25.5 × 4 = 102.0	0.0 × 4 = 0.0
28	39.5 × 3 = 118.5	100.0 × 3 = 300.0
48	25.3 × 2 = 50.6	0.0 × 2 = 0.0
100	4.8 × 1 = 4.8	0.0 × 1 = 0.0
Pan	0.1 × 0 = 0.0	0.0 × 0 = 0.0
	Total 300.0	Total 300.0

$$\text{Modulus} = \frac{300}{100} = 3.00 \qquad \text{Modulus} = \frac{300}{100} = 3.00$$

Uniformity = 0:7:3 Uniformity = 0:10:0

Final expression = 3.00 — 0:7:3 Final expression = 3.00 — 0:10:0

In figuring uniformity in Example 1, note that the first figure equals 0.48 and the second 6.50. It is impossible to convert the first over into one (1) and the second into seven (7), because the last number being three (3) the total would be 11. Since 0.48 is lower than 0.50, let the first figure equal 0; the second, 7; and the third, 3, viz., 0:7:3.

The above system has been approved by the joint committees of the two societies, and was adopted by the American Society of Animal Production at a meeting several months ago. It is the hope of our committee that the American Society of Agricultural Engineers will take similar action in the near future.

Author: Chairman, Committee on Feed Processing, American Society of Agricultural Engineers.

New Things in Farm Electric Applications

By J. P. Schaenzer

NEW ELECTRIC devices and equipment designed especially to assist the farmer in carrying on his productive farm enterprises are constantly appearing on the horizon. Observations made by men trained in agricultural engineering, and especially those in rural electrification, will substantiate that every one of these fills a particular niche in some specific farming operation. Although this is acknowledged as true, and in many instances considered a profitable investment, yet little of this equipment is used extensively on electrified farms.

To further substantiate this statement, the Committee on the Relation of Electricity to Agriculture, in cooperation with three electric utilities, conducted a survey of 142 dairy farms in one of the northern states. Dairy farms have always been considered as offering excellent opportunities for electric applications. These farms were located on three rural distribution lines. Every farmer connected to these lines was interviewed and a rather complete record made of his farming activities. The summary and final analysis revealed that the electric connected load used for productive farm enterprises was only ten per cent of the total. The balance was used for lighting, household appliances, and water pumping. If electricity is to be of the greatest economic value to the American farmer, this figure must be increased at least several times.

With electricity available to 1,250,000 American farms, this group of farms has a distinct advantage in increasing its cash income, or reducing the cost of production, or both. But how can this be accomplished? The feed grinder designed for the individual farm serves as an illustration in that it reduces the cost of processing feed. The milking machine cuts the milking time per cow and thus may enable the farmer to keep several more cows and thereby increase his cash receipts.

ELECTRIFICATION IN DIFFERENT TYPES OF FARMING

There is an increased effort among farmers to produce a quality product which commands a top price when placed on the market. Oftentimes these commodities are sold by the farmer directly to the consumer. The additional processes involved should increase the gross and net farm income. However, when this is done, the labor requirements of the farm may be multiplied considerably. As an illustration, an Indiana orchardist having 9,000 apple trees, not only produces apples of a superior quality, but also has controlled storage facilities and thus is enabled to market them under the most favorable conditions. To accomplish his purpose, he installed an electric motor-driven stationary spray plant whereby 12 men can spray the orchard in three days. The entire area is piped so that a maximum of 125 feet of hose will reach all trees. From early in the spring and throughout the growing season the trees are sprayed from nine to twelve times.

After the apples are picked, electric washers are used to remove all spray residues, and electricity operates the graders. All apples not sold at the time of harvest are placed in a mechanically refrigerated storage of 43,000-bushel capacity. All of these operations require labor, which should prove profitable to him.

The bulk milk producer multiplies his labor requirements appreciably by becoming a city or village milk retailer. It becomes necessary for him to bottle, cool, and perhaps pasteurize the milk before delivering it to the many individuals on his route. Upon his return to the farm, the bottles and equipment have to be washed, and perhaps even sterilized.

The same holds true for the truck gardener who begins irrigating his crops. It takes labor to irrigate. But, in return, he should secure an increase in quantity and a better quality of product. In addition, the labor requirements go up because of the higher yield. Many opportunities present themselves to the farmer, not only in producing high quality agricultural commodities, but also in marketing these himself to the ultimate consumer.

Farmers, the personnel of the state agricultural colleges, the research specialists of the manufacturing industry, and the rural service men of the electric utility companies, have all participated to a large degree in the development of new equipment for agriculture. Some of the electric applications developed recently for use on the farm are described briefly in this paper.

Electric-Motor-Driven Cultivator. This piece of equipment was developed by a Michigan florist and has been used by him with entire satisfaction for the past six growing seasons. It would seem that it has a practical application on many small farms where intensive cultivation is the regular practice.

This florist has 20 acres, of which fifteen are under cultivation. The plot is narrow and long in shape, being only 300 ft wide. No horses are kept on the farm. A neighbor is engaged annually to do the plowing and disking. All other cultivation of the soil is done with the electric-motor-driven cultivator.

The cultivator came equipped with a 1-hp gasoline engine. The latter was replaced with a 1-hp, variable speed, 1800/700, 200-volt, single-phase, ball bearing electric motor. By means of a speed reducer and sprockets, the ground travel of the cultivator has been limited to 2 mph.

A two-wire trolley line, 2,000 ft long and equipped with a three-wheel car, was built the length of the farm to transmit electric energy to the motor. A reel holding 150 ft of rubber-covered cable is mounted on the cultivator. This cable and the one hanging from the car are connected to deliver energy to the motor. The cultivator cable winds and unwinds on the reel as the operator travels perpendicularly to and from the trolley. Starting and stopping are easily controlled by means of a switch installed on the handle. The energy consumption amounts to less than 2 kwh per acre per cultivation.

Scalding and Waxing Equipment for Poultry. Poultry semiscalders have been developed in both Massachusetts and Minnesota. This method of dressing poultry calls for accurate temperature control. Tanks electrically heated and thermostatically controlled are ideal equipment in that the water can be maintained at a constant temperature. Semi-

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Presented before the Southern Section of the American Society of Agricultural Engineers at Atlanta, Ga., February 3, 1938.

Author: Assistant director, Committee on the Relation of Electricity to Agriculture. Chicago, Ill. Mem. A.S.A.E.

scalders are available in various sizes and come equipped with the correct size of heating element.

After the feathers have been removed, the dried bird is dipped into the tank of melted wax. This tank is also equipped with an electric heating element and thermostat. When the wax is set, it is peeled off, and with it comes the pin feathers. The cost of energy per bird is negligible when a large number of them are dressed at one time.

Poultry Floor Scraper. An electric-motor-driven poultry floor scraper has been designed and built by a Washington farmer. The scraper, 24 in wide, is constructed of heavy sheet metal. A spring arrangement holds it against the floor. A 1/3-hp, split-phase electric motor vibrates the scraper back and forth with about a 3-in stroke and scrapes the floor as it is pushed along. It reduces the time of cleaning about one-half.

Automatic Time Poultry Feeder. The purpose of this poultry feeder, also developed in Washington, is to distribute scratch feed over the floor at any predetermined time. It makes possible the feeding of poultry at regular intervals regardless of whether or not anyone is there to feed them.

The required amount of feed is placed in the hopper and then fed through a pipe onto a disk. When the time switch starts the motor and revolves the disk, the grain is spread over the feeding area. When this is accomplished the motor stops.

Homemade Electric Pig Brooder. The simplest type of pig brooder, first used on the West Coast, is built out of two 12-in boards, 3½ ft long, nailed together at right angles and boarded over on the top side. A hole cut in the top accommodates a 12-in white enameled reflector equipped with a 100 or 150-watt incandescent lamp. This furnishes both heat and light. The brooders are generally used for a period of ten days to two weeks per litter. Users have found through its use that they are oftentimes able to double the number of pigs raised and produce better and heavier animals.

COLD AND HEAT TO ORDER FOR FARM APPLICATIONS

All-Purpose Farm Refrigerator. Engineers of Oregon recently designed and built an all-purpose electric refrigerator for the farm. The novel feature of this refrigerator of 29-cu ft capacity is that it has a compartment of 7 cu ft for freezing and holding meat, fresh vegetables, and fruits for long periods. More than 200 lb of cut and wrapped meat can be stored in it at one time. The other 22 cu ft provide refrigeration for a 10-gal can of cream, hooks for hanging meat for cooling and curing, ample shelf area for perishable household foods, and products to be sold. Two large trays can be used for making ice cubes or two quarts of frozen dessert. A 1/3-hp electric motor, with compressor, is installed in the cabinet as a part of the refrigerator unit.

Electric Heat for Laying Houses. Poultrymen have oftentimes experienced financial losses because of a drop in egg production after a cold spell. This can be avoided by supplying artificial heat. Oftentimes the financial loss will offset the initial cost of an adequate heating system.

Extensive investigations in the application of electric heat in laying houses have been carried on for the past three winters by the Idaho Agricultural Experiment Station. An 880-watt circulating type of heater was installed in a 20x40-ft pen. The fan has a capacity of 225 cu ft of air per minute, and the heater raises this volume of air 15 F (degrees Fahrenheit). The equipment is thermostatically controlled so as to go on at 35 F.

This electric heating equipment has been used successfully for three years with outside temperatures as low as –30 F. The energy consumption for well-insulated houses was only one-third of that for those not insulated. The cost of operation compared favorably with coal-heated houses.

Electric Steam Boiler for the Dairy. Ordinances passed in certain cities of Oregon created a demand in dairies producing from 100 to 500 quarts of milk daily, for hot water and live steam for equipment sterilization. This resulted in the construction of a low-wattage electric boiler to produce steam at from 60 to 75 lb pressure. It is built in two sizes—30 and 60 gal. The boiler is made of ¼-in steel boiler plate, covered with 5 in of insulating material, and enclosed in a sheet-iron jacket. The electric heating element may be as small as 600 watts, or as large as 3,000 watts for 24 hr continuous operation. It is controlled with a pressure switch which opens the circuit when the boiler is up to pressure. It is equipped with a safety valve and water and pressure gages.

The energy consumption ranges from 600 to 1,500 kwh per month, and the cost of operation compares favorably with other fuels.

THE "HOT SEAT" FOR MURDEROUS INSECTS

Insect Electrocuting Light Traps. For more than a decade insect electrocuting light traps have been investigated by members of the staff of the University of California. One of the chief advantages of this method of control is that it obviates poisonous residues on fruit.

Laboratory tests indicate that insects have decided color preferences. Thus it is possible with different colored lights to bring to their destruction only those insects which are pests, and to exclude the beneficial ones. Field tests of such traps quickly produced evidence indicating the practical value of this method of insect control.

One type of insect electrocutor is 8 in in diameter and 18 in high. It consists of a wire cage of stainless steel. Alternate wires are connected to a high-tension transformer located in the metal container which supplies enough voltage to electrocute the insects and also furnish current for the luminous tube. The tube, helical in shape, is used as a lure, and is suspended in the center of the cage so that the insects will come in contact with the wires as they fly toward the light.

Satisfactory field tests have been conducted over a period of years to control the grape leafhopper, artichoke plume moth, codling moth, tomato insects, mushroom insects, dried fruit insects, and the lima bean pod borer.

White incandescent lamps of 60 to 300-watt intensity are used in the insect electrocutors where protection against annoying insects in general is desired. Remarkable results have been achieved in giving protection to people at service stations, outdoor cafes and taverns, swimming pools, summer resorts, outdoor theatres, garden parties, or family enjoyment.

An entirely new field for light traps has emerged in that the electrocuted insects are extensively used as food for fishes, frogs, and birds. The traps have also been installed in poultry yards to supply natural insect food to turkeys, chickens, pheasants, and quail.

Conclusion. It would be possible to continue with discussions of seed corn driers, irrigation for humid regions, quick freezing of vegetables and fruits, the all-electric greenhouse, electric milk pasteurization, sweet potato curing and storage, lights for growing plants, house cooling, and many other new applications. However, it should not be necessary to go on further in order to appreciate that continuous progress is being made in the development of new electric equipment for use on the farms of the United States.

Land-Use Planning or Land-Use Policy in the United States

By S. von Ciriacy-Wantrup

FEW TECHNICAL terms have come so rapidly into general use in recent years, not only in the United States but all over the world, as the term "land-use planning." If it means that a planning agency should plan the best use of specific units of land and should advise or induce people to follow such plans, it implies more, I think, than is feasible at the present state of our knowledge. What can be done and should be done, however, is to set up certain general rules of land use through legislation, within the framework of which the people can do their own planning. What seems to be needed is a broad governmental land-use policy and a body of land-use legislation, based on thorough land-utilization studies.

This is not to say that the United States has not had any land policy heretofore. Actively or passively, land use has been influenced in many ways by governmental policies for a long time. The form in which the public domain was handled before the Homestead Act, and the Homestead Act itself, might be mentioned as far-reaching active land policies. More important may have been and may be the passive land policy of freedom to buy, sell, and rent land without restrictions. The land is looked upon as a piece of personal property with which owner and user can do as they please without regard to the effects upon society as a whole. As an outgrowth of this *laissez faire* land policy, costly damages to society occur through land destruction. Such practices, however, may be profitable for individuals. Before a new land policy is contemplated, a thorough analysis of the effects of past and present land policies should be made. It might be easier to arrive at a suitable land policy by modification and integration of existing policies than by ignoring their existence and attempting to superimpose upon them some new form of "land-use planning."

What should be the goals of a land policy? It can be regarded as uncontroversial that not the welfare of certain classes of the people utilizing the land, but the long-time welfare of the whole nation should be the objective of a land policy. Land ownership should be regarded as a trust by society to the individual, the terms of which change slowly but constantly with the changing needs of society. On the basis of the value standards of a given society, the social costs and the social returns of land-use practices should be considered, as well as the costs and returns to the individual land owner or user. A more refined system of social cost accounting is needed. If we compare our modern methods of business cost accounting with the methods used by our fathers and grandfathers, the latter look crude to us. Future generations might look in the same way upon our present crude methods of social cost accounting. If the social costs exceed social returns, in other words, if social damage is done, the government might act in various ways, as follows:

1 The government might do nothing until those individuals or groups who are damaged change the government peacefully or by force.

2 The government might reimburse the victims for the damage without direct effect upon land use.

3 The government, through legislation, might force the owners or users of the land to reimburse the victims for the damage, without direct effect upon land use.

4 The government might step in before the damage is done through land-use legislation and thereby prevent the actions which lead to the damage.

5 The government might step in before the damage is done, through land-use legislation, and reimburse the owners or users of the land for the additional costs arising to them out of this land-use legislation.

To make the discussion somewhat less theoretical, some practical examples of these five approaches open to a governmental land policy might be cited.

The passive attitude of governments toward social damages caused by land use and land tenure has been a major factor in a number of social upheavals. Reference might be made to the peasant wars in medieval Europe, to the French

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Author: Assistant professor of agricultural economics, University of California.

SOCIALLY DESIRABLE LAND-USE PLANNING BY PRIVATE OWNERS COULD BE ENCOURAGED BY FAVORABLE LEASE TERMS, LOWERING FIXED CHARGES ON LAND, AND ADAPTING THE UNIT OF OPERATION FOR MAXIMUM PRODUCTIVE USE AND CONSERVATION

Revolution, and to the continuous unrest in Spain and Russia.

The second approach is taken if the government takes care of the welfare of migratory and unemployed agricultural labor, laid off at the time when it can no longer be profitably used by individual enterprises, or makes big expenditures to avoid floods, partly caused by the destruction of vegetation in the watershed, or pays heavily to check the silting of navigable streams, harbors, and water reservoirs, caused largely by soil destruction upstream.

The third line of action is followed if the government requires mining companies and smelters to pay for the damage or nuisance they inflict on other parties. This approach is not often used for social damages caused by agriculture or forestry.

A preventive land policy without compensation to those affected by compulsory legislation is pursued by almost all European governments for the safety of cities, for public health, for watershed protection, for soil conservation, and for many other purposes. In the United States this policy has been largely confined to the cities.

The last-mentioned active land policy, with government assistance to those land owners or users who are affected, is common in Europe. It is an approach which has been taken in the United States here and there, and which has come into common use more recently, not in the form of compulsory legislation, but voluntarily as a feature of the Soil Conservation and Domestic Allotment Acts.

SOCIAL COSTS TO BE BORN BY ECONOMIC ACTIVITY

What line of policy should be followed depends on the situation which is to be met. It should be a general principle, however, that every economic activity shall bear the full amount of social costs caused by that activity. Society should bring pressure upon the individual at the point where economic decisions are made rather than wait until the decisions are made and then remain passive or take purely defensive action. The first two lines of government action should therefore not receive major consideration for a proposed land policy. On the other hand, there should be full freedom for individual initiative to do its own land planning within the framework of such land-use legislation as that mentioned under points 3, 4, and 5.

One aspect of the social damage of land use is important not so much from a theoretical as from a practical standpoint. Social costs may consist in actual damage and nuisance to society, or in a less than optimal employment of resources, resulting in a lower return to society than could be obtained otherwise.

An efficient government should combat actual damage and nuisance to society not only by education, demonstration, and subsidies, but by a compulsory land-use legislation. Such legislation might affect land use indirectly or directly.

By indirect effects upon land use we mean legislation which would eliminate obstacles preventing private initiative from using the land properly, or which would introduce stimuli inducing a socially desirable land planning by individuals. Such legislation would deal with land taxation, land credit, land tenure, land inheritance, and land sales. A good example is the proposed tenancy legislation in the United States, although it may prove insufficient in the present form.

By direct effects we mean the exclusion of certain types of land use from definite areas, or the permission of certain uses, only if some precautionary regulations are followed. A beginning in this direction is the proposal of a "state soil conservation district law" prepared by the U. S. Department of Agriculture. It proposes the establishment of "soil conservation districts," somewhat after the pattern of irrigation and drainage districts. After their establishment through democratic procedure, these districts would have authority to impose local land-use regulations deemed necessary in order to avoid social damages from private land use. It might be mentioned in this connection that banks also should stipulate minimum conservation practices on farms on which they make loans.

OPTIMAL USE HIGHLY VARIABLE AND INTANGIBLE

We come now to the discussion of the second aspect of social costs, namely, to cases in which national resources are not utilized by individuals in the optimal way from the standpoint of society. It has already been said that these cases are theoretically similar to those of actual social damage. They are quite different, however, for practical land policies. Differences of opinion as to the optimal employment of resources will occur under any set of social value standards. The meaning of the optimal employment of resources changes rapidly with changing economic conditions and is much more evasive than the damage actually felt by some groups of society. A less than optimal employment of resources, therefore, does not lend itself readily to strict governmental regulation. Shortcuts in education have not, in these cases, demonstrated their superiority to the slower methods of improving the educational system and of increasing the sense of social responsibility among members of the social group in question. Besides, it is much easier to tell people what they should not do because it does actual damage to others, than to tell them what they should do in order to increase their own well-being, which they alone can judge.

This is the reason why some doubt has been expressed in the foregoing, as to whether the term "land-use planning" designates properly what is needed in the near future. We are told that the aim of land planning is to designate not only the best major uses of the land, but also to indicate for what special crops the land is best adapted. As long as such land planning remains at the stage of land surveys, it is useful. If it comes to advice, education, and demonstration, land planning will still do much good. But if land planning becomes an objective of a heavily subsidized or compulsory governmental policy, the results might be disappointing. Incidentally this would mean going much further than "totalitarian" states like Germany and Italy have gone in their land policy. It seems to be a much more urgent task for the government to eliminate actual damage to society from land exploitation, through broad land-use legislation within which individual initiative can do its own land planning, than to attempt a government planning of the best use of the land.

To illustrate what is meant by a less than optimal employment of resources, let us take a concrete example. In the Appalachians, the Ozarks, the Sierras, and in other parts of the country, one finds a type of people sometimes called "mountaineers". Some government agencies want to move them out of their mountains and resettle them somewhere else, because their production per head, their standards of living, and their standards of education are low; because they use their so-called submarginal land resources inefficiently, and because they could be of greater usefulness for the nation in some other place. In spite of that a part of these people do not want to move. They are quite happy where they are. Should the government induce them through subsidies or compel them through legislation

to move? According to the line of thought just presented, the government should do so only if these people do actual damage to society. In some cases they do so by causing serious soil erosion, and the government should step in in such cases. But very often they do not do actual damage.

It has been said that they do not produce a surplus for the markets of the nation and do not help business by their consumption. That is true, but do they not produce a surplus of children who might be valued very highly by the nation sometime in the future? Have they not, as well as more prosperous agricultural sections, offered shelter to many unemployed of the cities who streamed back to the land to weather the storm of depression?

It has been said that the nation does not want a larger quantity of children but a better quality, and that the poor mountaineer districts breed immorality and are danger spots to the American civilization. I am not so sure about that. I am rather inclined to see the danger spots in some big industrial cities with excellent school systems. As to the morals of the mountaineer people, they may be different from those of other sections of the country, but certainly not worse. It is rather difficult to see the advisability of forcing another way of life upon the so-called backward rural communities. A better way seems to be to leave them where they are, to build up the forest resources around them, and to give them more part-time employment in the national forests.

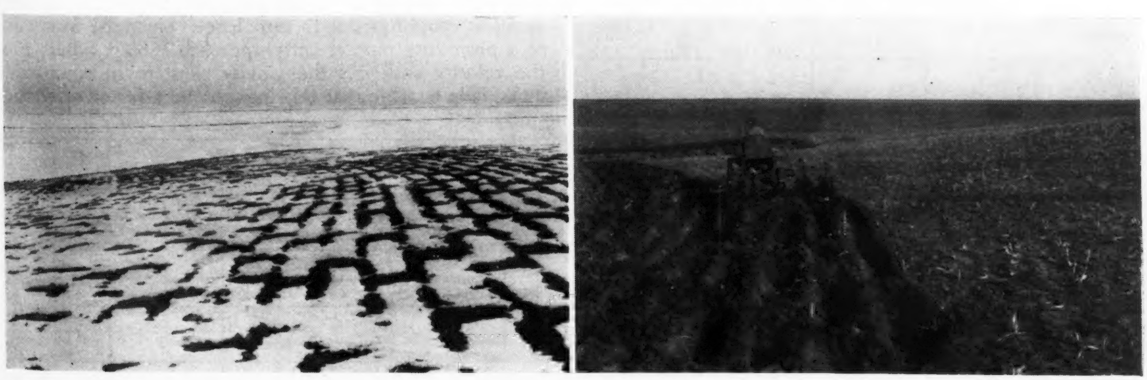
Let us look somewhat closer into the obstacles to socially desirable land planning by individuals. There are regions of the country where government land planning would not be very effective if these obstacles were not removed. They should therefore be removed first, and one should then await the results of private initiative.

The most important obstacle of this kind is the prevalent type of land leasing. A short-term lease without compensation to the tenant for improvements, or to the landlord for damages by the tenant, and a rent in the form of a share on the cash crop, must always and necessarily lead to exploitative methods of land use. A government land policy directed toward increasing the duration of leases, toward establishing a sound procedure of compensation to tenants and landlords, and toward abolishing the system of share renting, could do much to eliminate mismanagement of the land. The establishment of local tenancy courts consisting of laymen—landlords and tenants—serving in honorary capacity under the direction of a judge, might be considered as administrative units in such a land policy. There is no reason why, under good tenancy legislation, tenant farmers could not manage their land as well as owners.

The second obstacle to socially desirable land-use planning by private initiative is high fixed charges on the land. Theoretically, a man burdened with an unbearable tax or interest load would do better to sell the land instead of trying to meet the charges through exploiting the land. That, however, is difficult in times of depression when land values are low and when there is no other place to go. The owner's equity in the land may be so far reduced that not the selling but the mining of the land is the most profitable procedure from his private standpoint. If land owners cannot be made responsible for this reduction of the equity, which so frequently occurs in times of general changes of prices and land values, government land policy should be primarily directed toward an adjustment of the fixed charges.

The third obstacle which is difficult for the individual to overcome is the size of the unit of operation. In some cases the unit of operation is too small for good land management. The endeavor to keep up the customary standard for the farm family on too small a unit also tends toward mining of the land. In other cases, the unit of operation might be too large to allow the intensity per acre which is required for land conservation. The size of the operating unit is not a result of economic forces alone. Historical and political factors affecting land ownership have played and are playing an important role. Government land policy should be so directed as to favor those size groups which are economically and socially desirable. Taxation, credits, and direct resettlement might be used. Good tenancy legislation has importance from this standpoint also, because it tends to make the unit of operation less dependent on the unit of ownership.

If these obstacles to effective private land planning are overcome through a governmental land policy, if broad rules of land use are established through land use legislation, and if this legislation is effectively administered and enforced locally through the soil conservation districts mentioned above, one can hope that private initiative in land-use planning will achieve the same socially desirable results as it has in other countries. All lands which cannot be utilized profitably by private initiative under such land-use legislation should be taken over by the government and protected. This rich and free country has a singular opportunity to combine governmental land-use legislation with individualistic land-use planning.



(LEFT) A SPRING SNOW HELD ON A KANSAS FIELD TO MELT INTO THE SOIL WITH MINIMUM RUNOFF WASTE. (RIGHT) DAMMING CHISEL OR LISTER OPERATED ON THE CONTOUR TO PUT THE FIELD AT THE LEFT IN CONDITION TO HOLD SNOW AND RAIN

Water Transmission and Distribution for Irrigation

By H. D. Bruhn

WITH THE increased use of the portable rotary sprinkler system of irrigation has come the problem of selecting the proper pipe or tube sizes for the various parts of the system. Erroneous assumptions in the selection of pipe or tubing for the distribution system lead to either a system of high initial cost, or a system on which the operating costs are higher than necessary, or both. Therefore, there are two problems: first, to proportion the various parts of the system, and, second, to balance the original cost of the system against the operating costs.

The problem of proportioning the system can be attacked in a mathematical manner. Judgment must be used to balance the original cost of the system against the operating costs. In brief, in a system that is to be used for a comparatively short time each season, smaller and less expensive pipe or tubing (obviously of higher friction loss) should be used than should be selected for a system that is to operate over a greater part of the season and possibly to the extent of 24 hr per day. In an extensively used system such proportions should be selected that the pressure drop due to friction is low throughout the system.

In the choice of pipe or tube size, consideration must also be given to the fact that many different sizes of pipe or tube in the same system are liable to cause bother and confusion. For this reason, therefore, it is desirable to confine the system to two different sizes, or possibly three, where a long main is to be used.

On the assumption that the tubing used for irrigation systems has a friction factor equal to that of fairly smooth pipe, and from calculations based on outside diameter tubing of 16-gage material, the curves in Figs. 1 and 2 were developed. These curves show pressure head loss due to friction per 100 ft of tube for various rates of discharge.

In the following discussion the standard sprinkler head will be defined as one which will pass 16⅔ gal of water per minute. This discharge is necessary to put on ½ in of water per hour at the customary 40-ft spacing of sprinkler heads on the sprinkler line and 80-ft sprinkler line outlet spacing on the main.

After several systems had been calculated, it was found that there is a fair rule-of-thumb method of determining tube size. This rule is: The square of a given tube diameter equals the number of sprinkler heads to which the tube can supply water. The tube of large size can carry somewhat over this amount, while with the smaller sized tubing the number must be reduced somewhat.

Therefore, once the length of the desired sprinkler line is chosen, the layout can be followed in an orderly manner.

For example, it is desired to lay out a system having a 1000-ft sprinkler line and a 1000-ft main. Sprinkler head spacing along the line is usually at 40-ft intervals. Therefore, a 1000-ft sprinkler line requires 25 sprinkler heads. If the square root of 25 is extracted, a sprinkler line of 5-in diameter is indicated. Since 5-in tubing is rather heavy to handle, it will be desirable to reduce the sprinkler line size to 4 in over as much of the line as is possible without too great a friction loss.

The next step is the actual calculation of the friction losses. The sprinkler heads are numbered starting at the main. In Table 1, the total of the individual values in column 4 represents the loss of head in feet due to friction in the sprinkler line. To this total is added the head loss due to friction in the main, and the sum obtained represents the total friction loss in main and sprinkler line. On an average, the 16⅔-gal sprinkler head requires a pressure of 35 lb per sq in at the head. By converting this pressure to feet of water and adding it to the friction losses, plus the difference in elevation of the pump and sprinkler heads, the total pressure head on the discharge side of the pump is obtained. Tables 2 and 3 show the sums of the friction losses and the pressure necessary to operate the sprinkler heads.

In this discussion no reference has been made to head losses at couplings due to turbulence. Since the losses due to a projecting pipe at entry approach $V/2g$, where V is the velocity and g is the gravity constant in comparable units, it is possible that this loss can be a factor of consid-

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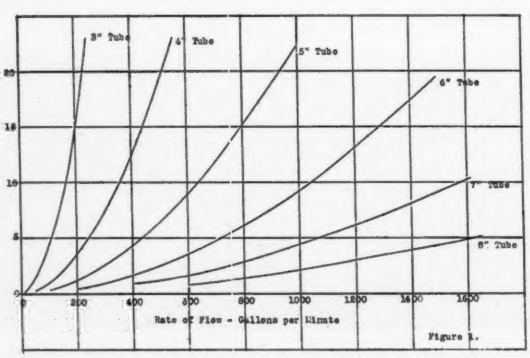
Author: Research agricultural engineer, University of Wisconsin.



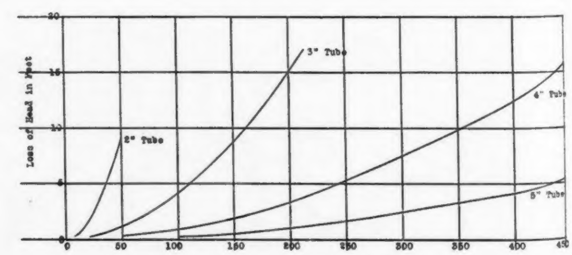


FIG. 1 (LEFT) AND FIG. 2 (RIGHT) LOSS OF HEAD IN FEET DUE TO FRICTION, PER 100 FEET OF FAIRLY SMOOTH TUBING

TABLF 1. METHOD OF DETERMINING HEAD LOSS DUE TO FRICTION IN DISTRIBUTION SYSTEM

Section of tubing between sprinkler heads	Flow, gal per min	Size of tubing, O.D., in	Loss of head in feet, due to friction
24 and 25*	16.66	4	0.02
23 and 24	33.33	4	0.06
22 and 23	50.00	4	0.12
21 and 22	66.66	4	0.20
20 and 21	83.33	4	0.24
19 and 20	100.00	4	0.40
18 and 19	116.66	4	0.48
17 and 18	133.33	4	0.60
16 and 17	150.00	4	0.72
15 and 16	166.66	4	0.88
14 and 15	183.33	4	1.08
13 and 14	200.00	4	1.32
12 and 13	216.66	4	1.56
11 and 12	233.33	4	1.80
10 and 11	250.00	4	2.08
9 and 10	266.66	5	0.72
8 and 9	283.33	5	0.84
7 and 8	300.00	5	0.96
6 and 7	316.66	5	1.04
5 and 6	333.33	5	1.20
4 and 5	350.00	5	1.28
3 and 4	366.66	5	1.40
2 and 3	383.33	5	1.48
1 and 2	400.00	5	1.60
0** and 1	416.66	5	1.72
	Loss of head in feet due to friction in sprinkler line		23.80
	Loss of head in feet due to friction in main		43.00
	Total loss of head in feet due to friction in main and sprinkler line		66 80

* Sprinkler No. 25 is the sprinkler farthest from the main.

**The "0" position is the point at which the sprinkler line connects with the main.

erable magnitude in a poorly designed system, dependent, of course, on the coupling and the velocities. V, of course, varies inversely as the square of the diameter of the tubing. Also it can be shown that h_F is proporional to $f\ (LQ^2/d^5)$ where h_F is the loss in head due to friction, L is the length of tube, Q is the quantity of water, d is the diameter of the tube, and f is a friction factor that remains practically constant for moderate values of d and V. Thus, if L and Q remain contant, h_F varies inversely as d^5.

Therefore, if a coupling is used in which considerable turbulence develops, it is doubly desirable to use a tube of large enough diameter to conduct the water at a low velocity. In the tables included in this paper the friction losses set forth are sufficiently high to cover both the losses in the tubing and in well-designed couplings. If a coupling is used in which the friction losses due to turbulence are expected to be high, modifications must be made.

In Table 1 the loss of head due to friction has been calculated for a sprinkler line made up of 4 and 5-in tubing. In Table 4 the loss of head due to friction is shown for two sprinkler lines of the same length as that given in Table 1; however, one of these lines consists entirely of 4-in tubing, while the other consists entirely of 5-in tubing. The sprinkler line made up of 4 and 5-in tubing is called the "A" system; the sprinkler line consisting of 4-in tubing, the "B" system; and the sprinkler line consisting of 5-in tubing, the "C" system. The following set of calculations is carried through to show that the extra cost of the 400 ft of 5-in tubing in the "A" system is justifiable, while the extra cost of an entire sprinkler line of 5-in tubing such as is used in the "C" system is not justifiable from an economic standpoint.

Assume 20 days use, 20 hr per day, 416 gal per min, and pump efficiency of 70 per cent.

DIFFERENCE BETWEEN SYSTEM "B" AND SYSTEM "A" IN POWER REQUIREMENT, OPERATING COST, AND ORIGINAL COST

Power Requirement. Difference in head losses: 49.9 — 23.8 = 26.1 ft (Tables 1 and 4). Difference in horsepower required to operate the systems:

$$\frac{26.1 \times 416 \times 8.35}{33{,}000 \times 0.70} = 3.92 \text{ hp.}$$

Operating Cost. Difference in operating cost: 3.92 hp at 3 cents per horsepower-hour for 400 hr of operation = \$47.10 per season.

Original Cost. Difference in cost between 4-in and 5-in tubing, about 12 cents per foot: 400 ft at 12 cents = \$48.00.

Thus the saving in operating cost for one year practically pays for the difference in the original cost.

DIFFERENCE BETWEEN SYSTEM "A" AND SYSTEM "C" IN POWER REQUIREMENT, OPERATING COST, AND ORIGINAL COST

Power Requirement. Difference in head losses: 23.8—15.89 = 7.91 ft (Tables 1 and 4). Difference in horsepower required to operate the systems:

$$\frac{7.91 \times 416 \times 8.35}{33{,}000 \times .70} = 1.19 \text{ hp.}$$

TABLE 2. SPECIFICATIONS OF SPRINKLER LINE*

Length of sprinkler line ft	Number of sprinkler nozzles	Gal per min**	Size of sprinkler line, in inches*** Up to five nozzles	For 2nd five nozzles	For 3rd five nozzles	For 4th five nozzles	For 5th five nozzles	For 6th five nozzles	For 7th five nozzles	For 8th five nozzles
40	1	17	1¼							
80	2	33	1½							
120	3	50	2							
160	4	67	2½							
200	5	83	3							
400	10	167	3	3						
600	15	250	4	4	4					
800	20	333	4	4	4	4				
1000	25	417	5	5	4	4	4			
1200	30	500	6	6	6	4	4	4		
1320	33	550	6	6	6	6	4	4	4	
1400	35	583	6	6	6	6	4	4	4	
1600	40	667	6	6	6	6	6	4	4	4

* This table is based on 16-gage steel tubing for sizes of 3 in and over. The sizes up to and including 2½ in are based on standard iron pipe, although tubing and fittings can be obtained in the 2 and 2½-in sizes if desired. All tubing sizes of 3-in and larger, are for outside diameter (O.D.) dimensions. Standard pipe sizes are based on inside diameter (I.D.)

** This column is based on a discharge of 16.67 gal per min, per nozzle, which will apply ½ in of water per hour, if the nozzles are spaced at 40-ft intervals along the sprinkler line and with sprinkler line positions 80 ft apart.

*** The sprinkler line must be large next to the main, as this portion must carry the water for all of the nozzles. The line can and should be reduced in size toward the end. The first column headed "Up to five nozzles" gives the recommended size of pipe or tubing for this portion of the line. For example, if the line is 1000 ft long, the tubing should be 5 in in diameter for the first five nozzles (200 ft) next to the main. The next column shows that 5-in tubing should be used for the next 5 nozzles, or the next 200 ft. The next 3 columns show that 4-in tubing should be used for the balance of the line.

TABLE 3. SPECIFICATIONS OF THE MAIN AND THE PUMP

Number of sprinkler nozzles	Gal per min	Length of main*: Up to 1000 ft — Size of main, in	Up to 1000 ft — Pressure at pump, ft	1000 to 2000 ft — Size of main, in	1000 to 2000 ft — Pressure at pump, ft	2000 to 3000 ft — Size of main, in	2000 to 3000 ft — Pressure at pump, ft	3000 to 4000 ft — Size of main, in	3000 to 4000 ft — Pressure at pump, ft
1	17	1¼	150	1½	140	2	115	2	125
2	33	2	135	2½	120	2½	135	2½	150
3	50	2½	115	2½	150	2½	180	3	150
4	67	2½	150	3	135	3	160	3	185
5	83	3	120	3	155	4	105	4	115
10	167	4	130	4	150	5	130	5	140
15	250	5	110	5	125	5	145	6	115
20	333	5	135	6	130	6	145	6	155
25	417	5	145	6	135	6	155	7	135
30	500	6	125	6	150	7	135	7	145
33	550	6	130	6	160	7	140	7	155
35	583	6	135	7	135	7	150	8	135
40	667	6	150	7	150	8	140	8	150

*Sizes up to and including 2½ in are calculated for pipe, all over 2½ in are for steel tubing, and the sizes for tubing refer to the outside diameter (O.D.) of the tube. The columns "Pressure at the pump" refer to the pressures that will be necessary at the discharge of the pump, in order to overcome the friction in the pipe and still maintain a pressure of about 35 lb at the outer end of the sprinkler line. If the field is higher than the pump, this elevation, measured in feet, must be added to the figures in the columns headed "Pressure at the pump".

Operating Cost. Difference in operating cost: 1.19 hp at 3 cents per horsepower-hour for 400 hr of operation = $14.30 per season.

Original Cost. Difference in cost between 4-in and 5-in tubing, about 12 cents per foot: 600 ft at 12 cents = $72.00

On this basis the additional cost of the larger tubing would hardly be justifiable from an economic standpoint, and since the 5-in tubing is somewhat harder to move, the *"A"* system would be undesirable.

Horsepower required for the "T" system with 1000 ft of 5-in main and a 20-ft difference in elevation between source of water and points of distribution:

Total lift, 145 + 20 = 165 ft

Rate of pumping: 416gal per min, or 3468.6 lb per min

Overall pump efficiency assumed as 70 per cent.

Power Requirement:
$$\frac{165 \times 3468.6}{33{,}000 \times .70} = 24.8 \text{ hp.}$$

In agreement with this is the rule-of-thumb statement that one horsepower is required per sprinkler head.

For small areas the sprinkler head of a capacity of 16⅔ gal per min is not entirely satisfactory. The pressure required is high and equipment is relatively expensive. Therefore, we have developed what might be termed a junior system in which the sprinkler spacing on the sprinkler line, the sprinkler line spacing, and the pressure at the sprinkler heads have been reduced to approximately one-half of what they are in a typical standard system. In this junior system the sprinkler heads are spaced at 20-ft intervals, and the sprinkler line is moved 40 ft per setting. These sprinkler heads cover a circle about 45 ft in diameter at 4¼ gal per min, and with a pressure at the head of 20 lb per square inch.

The junior system has several advantages for irrigation of small areas of about 10 acres or less. The lower pressure greatly reduces the power requirmeent for pumping and also reduces the cost of pumping equipment. Furthermore, as soon as a distribution system is fabricated of thinner, lighter, and less expensive material than is used in present systems, it can be adapted here because such low pressures are used. In addition, the distribution system can be made of tubing of smaller diameter than that used in the standard system. The reason for this is the fact that the length of the sprinkler line is usually determined by a dimension of the area to be irrigated. Therefore, since the junior system covers only one-half the usual width per setting, obviously the flow of water in the distribution system is only half as much.

Another advantage of the junior system is that it seems to lend itself to package merchandising, which should result in lower costs. At present the standard systems are individually engineered and sold through expensive individual sales methods.

The disadvantages of the system are that the sprinkler line must be moved twice as often, and twice as much time is required to irrigate a given area as is required with the standard system. The last disadvantage is not considered serious because irrigation systems often are not used to the fullest possible extent and may lie idle a considerable portion of the time.

It is expected that the junior system will find a ready market in a field where the acreage to be irrigated is small. Here the standard system has been excluded because of the high original cost per acre.

TABLE 4. FRICTION LOSS IN TWO SPRINKLER LINES, ONE CONSISTING ENTIRELY OF 4-IN TUBING AND THE OTHER OF 5-IN TUBING

Section of tubing between sprinkler heads	Flow, gal per min	System B — Size of tubing O.D., in	System B — Loss of head in feet due to friction	System C — Size of tubing O.D., in	System C — Loss of head in feet due to friction
24 and 25	16.66	4	0.02	5	0.01
23 and 24	33.33	4	0.06	5	0.04
22 and 23	50.00	4	0.12	5	0.06
21 and 22	66.66	4	0.20	5	0.08
20 and 21	83.33	4	0.24	5	0.10
19 and 20	100.00	4	0.40	5	0.12
18 and 19	116.66	4	0.48	5	0.14
17 and 18	133.33	4	0.60	5	0.16
16 and 17	150.00	4	0.72	5	0.20
15 and 16	166.66	4	0.88	5	0.26
14 and 15	183.33	4	1.08	5	0.32
13 and 14	200.00	4	1.32	5	0.40
12 and 13	216.66	4	1.56	5	0.48
11 and 12	233.33	4	1.80	5	0.60
10 and 11	250.00	4	2.08	5	0.68
9 and 10	266.66	4	2.40	5	0.72
8 and 9	283.33	4	2.68	5	0.84
7 and 8	300.00	4	3.00	5	0.96
6 and 7	316.66	4	3.24	5	1.04
5 and 6	333.33	4	3.60	5	1.20
4 and 5	350.00	4	3.92	5	1.28
3 and 4	366.66	4	4.24	5	1.40
2 and 3	383.33	4	4.64	5	1.48
1 and 2	400.00	4	4.92	5	1.60
0 and 1	416.66	4	5.70	5	1.72
			49.90		15.89

Analysis of Border Irrigation

By M. R. Lewis and W. E. Milne

THE BORDER method of irrigation consists essentially in the division of the field by low flat levees into a series of strips, each of which is flooded separately. Ordinarily these strips extend in the direction of the steepest slope and at right angles to the supply ditch. The strips are made level transversely, but follow the general slope of the land longitudinally, with only sufficient smoothing to do away with adverse grades. Water is turned into the upper end of each strip and moves down the slope in a thin sheet. The system may be modified by making the strip at an angle with the line of greatest slope, but for most cases the slope of the border strip is fixed by the natural topography of the land.

Width of the strip may be governed by the topography, because the cost of leveling may be excessive if the strips are made very wide on rough land or that having considerable transverse slopes, or the character of the soil and subsoil may be such that deep cutting is prohibited on account of deleterious effects on the crop-producing powers of the soil. More often, however, the width of the borders is governed by the size of the irrigating head available and the possibility of securing proper distribution of the water.

Length of the border strip may be fixed by the topography, the location of ditches or property lines, or by the limit to which a stream of the maximum size that can be handled will flow before too much water has infiltrated at the upper end of the strip. The size of the stream may be limited by the size of the irrigation ditch, pump, or pipe line; the skill of the irrigator; or the danger of soil erosion.

The problem is to estimate in advance of actual trial the proper relations between the size of the irrigating stream, the width, and the length of the border strip.

Review of Literature. Both Parker (4)* and Israelsen (1) discuss the problem and develop a formula for the rate at which water will cover a border strip, with given values for the quantity of water applied, the depth of water on the surface, and the rate at which water is absorbed by the soil. In both cases the assumption is made that the rate of infiltration is constant throughout the period of irrigation. Israelsen points out that the percolation rate is not rigidly constant, either from time to time or from point to point in the field. He quotes data secured by Bark in Idaho and shows a graph comparing the experimental data with theoretical curves plotted on the basis of assumed values of both percolation rate and depth of water on the surface. There is a very wide discrepancy between the plotted curves and the experimental data. It would be possible to make curves which would coincide rather closely with the experimental data by assuming different values for the depth of water on the surface and the rate of infiltration. However, as Israelsen points out, the relation between the theoretical curves and the experimental data tends to show that the rate of infiltration was not constant throughout the period of irrigation.

Parker says "In actual practice P (the rate of infiltration) may be taken as 0.000,015 ft per sec, for water is absorbed by sandy fields at an average rate of 21 cusecs per million square feet and by a loamy field at a rate of 8 cusecs per million square feet." Both authors tacitly assume that there will be no waste from the lower end of the border.

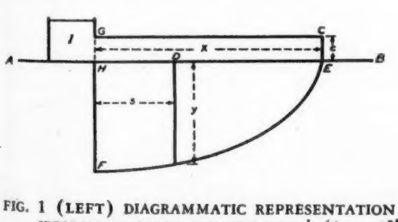
In Hydraulic Structures by Schoklitsch (5), the problem is approached from a slightly different angle, although the same assumptions as to uniformity of rate of infiltration and depth of water on the surface are made. Schoklitsch assumes that there will always be waste from the lower end of the strip and works out a relationship between the total amount of water delivered at the upper end of the strip to the total amount of water infiltrated into the soil. He says that this ratio is seldom less than 1.5 or 2, but that for the most efficient irrigation it should be near unity. All of these writers develop the relationship between the size of the irrigating stream and the area of land irrigated at a single run. None of them consider the ratio between the width and length of border, that is, none of them take into account the factors limiting the quantity of water per unit width of border strip.

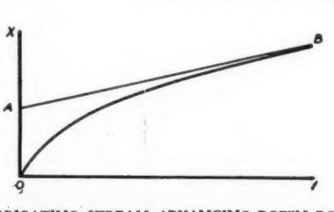
Muntz and Lainé (3) made extensive studies of the rate of infiltration and also made observations and experiments on border strips to determine the best size of irrigating stream. They noted the rapid infiltration when water first covered the soil, but found that after a time (an hour or so for sandy soil, but perhaps a day or more for heavy soils) the rate became uniform, and they used this uniform rate as their measure of "perméabilité." They found values of permeability in centimeters per hour, ranging from 0.1 to 60, equivalent to 0.00065 to 0.39 in per min. As a result of their field experiments, they adopt as a measure of the irrigating stream the quantity of water

[1]Based on data secured in irrigation investigations conducted cooperatively by the Bureaus of Agricultural Engineering and Plant Industry, U. S. Department of Agriculture, and the Oregon Agricultural Experiment Station. Approved for publication as Technical Paper No. 283 of the Oregon Agricultural Experiment Station. (First publication in AGRICULTURAL ENGINEERING.)

Authors: Respectively, irrigation engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture and soils department, Oregon Agricultural Experiment Station (Fellow A.S.A.E.), and head, department of mathematics, Oregon State Agricultural College.

*Numbers in parenthesis indicate references cited at the end of the paper.





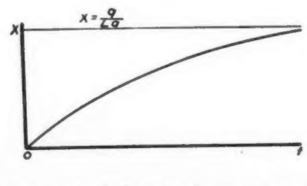


FIG. 1 (LEFT) DIAGRAMMATIC REPRESENTATION OF IRRIGATING STREAM ADVANCING DOWN BORDER STRIP. FIG. 2 (CENTER) ADVANCE OF IRRIGATING STREAM WHEN $y = b\ (1 - e^{-rt})$. FIG. 3 (RIGHT) ADVANCE OF IRRIGATING STREAM WHEN $y = at + b\ (1 - e^{-rt})$

applied per unit width of strip, and use the term "module" to designate this quantity. They report that the "module" should provide a flow of 0.3 liter per meter width of border strip per second for the tightest soil, 1.5 to 2.0 liters per meter width per second for medium soils, and 9 liters per meter per second for the extremely permeable soils. These values are equivalent to 0.003, 0.015 to 0.02, and 0.1 sc-ft per ft width of strip. They point out that these modules do not agree with those provided by the French irrigation systems on which they worked and they ascribe serious difficulties of certain projects to the poor judgment shown in this respect. These figures mean that 1 sec-ft of water should be supplied for each 10-ft width of strip on the sandier soils, each 50 to 65-ft width on the medium soils, and each 330-ft width on the heavier soils.

These workers, who made by far the most extended and careful studies of the border method of irrigation which the authors have seen, found both in field observations and by analysis of the problem that for any given rate of infiltration and any given module, there was a limit beyond which the water would not flow in border irrigation. They also point out that by the time water covered this maximum length of border, the depth infiltrated at the upper end of the strip would be excessive. They point out that the theoretically correct module for the tightest soil is so small that the water cannot be properly spread across the strip. From the fact that they report successful irrigation with modules corresponding to one second-foot on a strip 200 ft wide, it appears that the fields on which they worked must have been extremely well leveled.

Mathematical Analysis. A complete analysis of border irrigation would require information as to the effect of (a) slope, roughness of soil surface, vegetation, and depth of water on the velocity of flow down the slope, and (b) structure, texture, and moisture content of the soil, temperature of soil and water, vegetation and depth of water on the rate of infiltration. Moreover, practical application of the results would require information as to the extent of erosion by different depths and velocities of flow under different crop conditions and over different soil types, on the exactness with which border strips can be levelled transversely under ordinary farm conditions and on the limits of width of strips and of size of irrigating streams which can be used in actual field practice.

Both in the formulas presented by Parker (4), Israelsen (1), and Schoklitsch (5), and in that proposed herein, the depth of water on the surface has been assumed to be constant. No published data appear to be available on this factor, and, unfortunately, no measurements have been made in the field in these experiments. The factors governing the depth of flow are so many and so few data are available that no attempt has been made to reduce them to a formula. Even if this were possible, the introduction of another variable would add immensely to the difficulty of the mathematical treatment.

It might be contended that any rational formula for the advance of the irrigation stream should include the slope of the strip, a factor for the type of vegetation, one for the roughness of the soil surface, and one for the depth or quantity of flow, because each of these affects the velocity of flow. Careful consideration, however, shows that all of these are effective through their influence on the depth at which the water flows. If the vegetation or the irrigation head are increased, or the slope is decreased, the water will simply slow up until a great enough depth has accumulated to overcome these factors. Reverse conditions will result in flow taking place at a shallower depth.

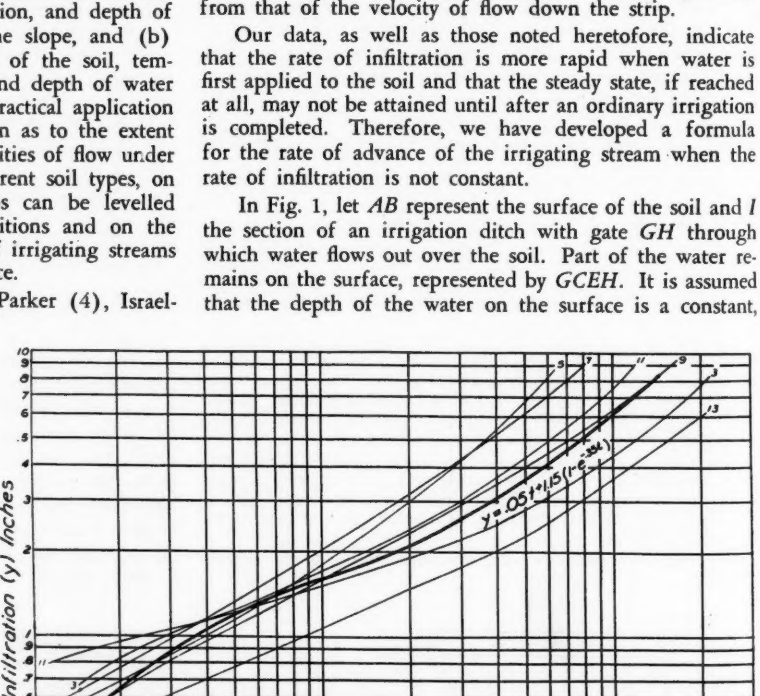
With short borders and low gradients the slope of the water surface may differ from that of the soil surface by reason of differences in the depth of water at various distances from the head ditch, but with borders of considerable length and moderate or steep slope, the slope of the water surface must be substantially that of the ground surface.

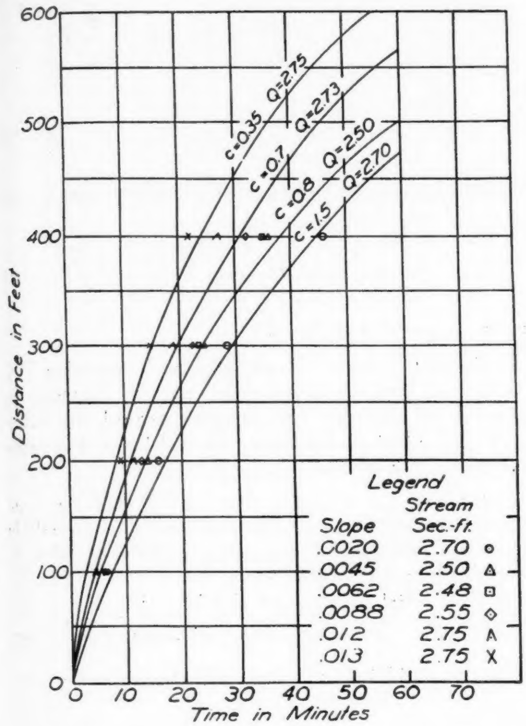
For these reasons it is believed that the depth may be considered uniform and the problem of the rate of advance, as affected by rate of infiltration, be attacked separately from that of the velocity of flow down the strip.

Our data, as well as those noted heretofore, indicate that the rate of infiltration is more rapid when water is first applied to the soil and that the steady state, if reached at all, may not be attained until after an ordinary irrigation is completed. Therefore, we have developed a formula for the rate of advance of the irrigating stream when the rate of infiltration is not constant.

In Fig. 1, let AB represent the surface of the soil and I the section of an irrigation ditch with gate GH through which water flows out over the soil. Part of the water remains on the surface, represented by $GCEH$. It is assumed that the depth of the water on the surface is a constant,

FIG. 4 DEPTH OF WATER INFILTRATED IN DIFFERENT TRIALS ON THE UMATILLA FIELD STATION





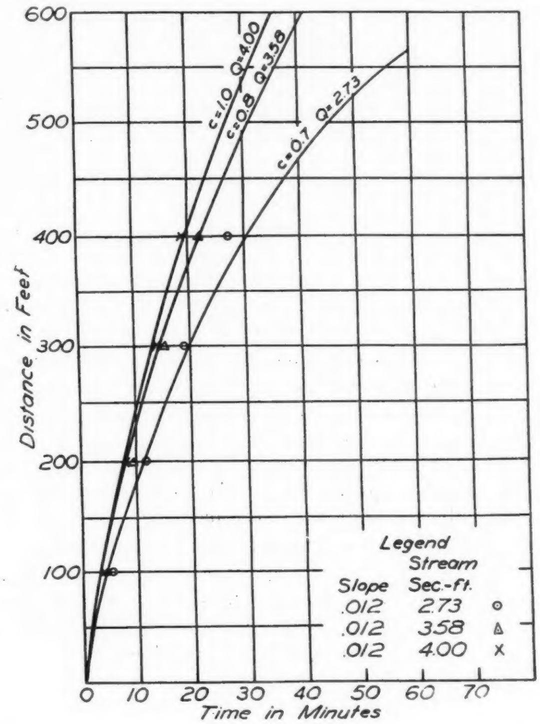


FIG. 5 (LEFT) OBSERVED RATE OF ADVANCE OF IRRIGATING STREAM DOWN BORDER STRIPS WITH DIFFERENT SLOPES ON THE UMATILLA FIELD STATION, AND COMPUTED CURVES. FIG. 6 (RIGHT) OBSERVED RATE OF ADVANCE OF DIFFERENT SIZES OF IRRIGATING STREAMS DOWN BORDER STRIPS ON THE UMATILLA FIELD STATION, AND COMPUTED CURVES

which is denoted by c. Part sinks beneath the soil, represented by EFH.

The following notation is employed:

- y denotes depth in feet of the column of water that has penetrated at D.
- x denotes the distance HE in feet.
- t_x denotes time in minutes required for the water front to travel from H to E.
- s is the distance from H to D.
- t_s is the time in minutes required for the water front to travel from H to D.
- q is the number of cubic feet per minute flowing through the gate GH.
- L is the width of the irrigated strip (perpendicular to the paper in Fig. 1), and also the width of the gate GH.

Then the total volume of water which has flowed through the gate at time t_x is

$$V = qt_x$$

while the total volume of water above and beneath the soil is

$$V = L \text{ (Area } GCEF)$$

$$= L\int_o^x (c+y)\, ds.$$

Therefore, we have the fundamental equation

$$qt_x = L\int_o^x (c+y)\, ds. \qquad [1]$$

Now at the point D in Fig. 1 the length of time that the water has covered the surface is

$$t = t_x - t_s,$$

so that the argument of y in equation [1] is $t_x - t_s$.

The equation [1] can then be written as follows:

$$\frac{q}{L} t_x = \int_o^x c\,ds + \int_o^x y\,(t_x - t_s)\, ds,$$

or

$$cx = -\int_o^{t_x} y(t_x - t_s)\frac{ds}{dt_s}\, dt_s + \frac{q}{L} t_x.$$

If we use primes to denote derivatives with respect to t_x we have

$$\frac{ds}{dt_s} = x'\,(t_s),$$

so that the equation above can be put in the final form

$$cx = -\int_o^{t_x} y(t_x - t_s)\,x'(t_s)\, dt_s + \frac{qt_x}{L}. \qquad [2]$$

Successive differentiations with respect to t_x give

$$cx' = -\int_o^{t_x} y'(t_x - t_s)\,x'(t_s)\, dt_s + \frac{q}{L}, \qquad [3]$$

since $y\ (0) = 0$;

$$cx'' + y'_0x' = -\int_0^{t_x} y''(t_x - t_s)x'(t_s)\,dt_s, \qquad [4]$$

$$cx''' + y'_0x'' + y''_0x' = -\int_0^{t_x} y'''(t_x - t_s)x'(t_s)\,dt_s, \qquad [5]$$

$$cx'''' + y'_0x''' + y''_0x'' + y'''_0x' = -\int_0^{t_x} y''''(t_x - t_s)x'(t_s)\,dt_s. \qquad [6]$$

The general solution of equation [2] appears to be rather difficult to obtain, but in the special case in which the function y is a solution of a linear differential equation of the nth order with constant coefficients, the value of x is easily found. For in this case the function y can be eliminated from equations [2], [3], etc., by multiplying each equation by the appropriate coefficient and adding. The resulting equation for x is a linear differential equation of the nth order with constant coefficients.

The procedure will be illustrated by two examples.

Example 1. Let $y = b\,(1 - e^{-rt})$. This type of absorption function is characterized by the fact that the initial rate of absorption is br, the rate decreases toward zero, and the total penetration approaches b as a limit.

The differential equation satisfied by y is

$$y' + ry = br. \qquad [7]$$

If now we multiply [2] by r, and add [3], we get by use of [7]

$$cx' + rcx = -\int_0^{t_x} brx'(t_s)\,dt_s + \frac{q}{L}t$$

or

$$cx' + r(b + c)x = \frac{qt}{L}. \qquad [8]$$

The particular solution of [8], which vanishes when $t = 0$, is

$$x = \frac{q}{Lr\,(b + c)}\left[t - \frac{1}{k}\,(1 - e^{-kt})\right], \qquad [9]$$

where $k = r(b + c)/c$.

The general behavior of the solution in equation [9] is shown in Fig. 2. The initial rate of advance is $2q/Lr(b + c)$, and the rate decreases toward the value $q/Lr(b + c)$, which is exactly half the initial rate. The curve approaches asymptotically the straight line AB.

Example 2. Let $y = at + b\,(1 - e^{-rt})$. This type of penetration is characterized by the fact that the initial rate is $a + br$, and that the rate decreases toward the value a, thus approaching a constant rate.

The differential equation satisfied by y is

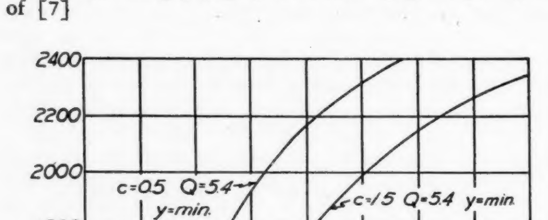
$$y'' + ry' = ar, \qquad y'_0 = a + br. \qquad [10]$$

Now multiply [3] by r and add [4], whereupon by [10] we get

$$cx'' + y'_0x' + crx' = -arx + \frac{qr}{L},$$

or

$$cx'' + (a + br + cr)x' + arx = \frac{qr}{L}. \qquad [11]$$



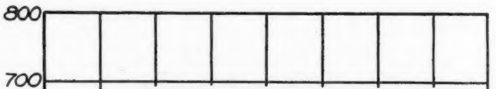


FIG. 7 (LEFT) ADVANCE OF IRRIGATING STREAM DOWN BORDER STRIPS AS COMPUTED WITH DIFFERENT VALUES OF C AND V. FIG. 8 (RIGHT) COMPARISON OF ADVANCE OF IRRIGATING STREAM DOWN BORDER STRIP, AS COMPUTED BY OLD AND NEW FORMULAS

If we let

$$\beta = \frac{a + br + cr}{2c},$$

$$\delta = \frac{\sqrt{(a + br + cr)^2 - 4\,arc}}{2c},$$

the solution of [11] which satisfies the initial conditions is

$$x = \frac{q}{L}\left[\frac{1}{a} - \frac{e^{-\beta t}}{a}\left(\frac{e^{\delta t} + e^{-\delta t}}{2}\right) + \left(\frac{1}{c\delta} - \frac{\beta}{a\delta}\right)e^{-\beta t}\left(\frac{e^{\delta t} - e^{-\delta t}}{2}\right)\right], \qquad [12]$$

which may also be written in the form

$$x = \frac{q}{La}\left[1 - e^{-\beta t}\cosh\delta t + \left(\frac{a}{c\delta} - \frac{\beta}{\delta}\right)e^{-\beta t}\sinh\delta t\right]. \qquad [13]$$

The general character of the solution is shown in Fig. 3. The initial rate is q/cL, and the rate diminishes toward zero while x approaches asymptotically the horizontal line $x = q/La$.

Obviously by assuming that y is a solution of a differential equation of higher order, say, third or fourth, it will be possible to obtain a still larger variety of forms for the penetration function and also to obtain forms that approximate more closely to any given set of experimental data. It is felt, however, that the two types illustrated above are as complex as present data justify.

Experimental Results. In 1933 and 1935 experiments were carried on at the Umatilla field station of the Bureau of Plant Industry, U. S. Department of Agriculture and Oregon Agricultural Experiment Station, on the rate of infiltration of irrigation water and also on the rate of advance of the irrigation stream. The infiltration experiments have been reported heretofore (2). Essentially the tests were made by driving 18-in diameter rings into the soil, pouring water into the rings and noting the rate at which the water infiltrated into the soil.

Fig. 4 shows the results of a number of these tests. The data have been adjusted to conform to a uniform moisture content at the beginning of the period of infiltration. The curves include the maximum, minimum, and several intermediate rates of infiltration as disclosed by a series of 17 measurements made on and near the Umatilla field station. On this figure the heavy line represents the curve $y = 0.05t - 1.15\,(1 - e^{-0.35t})$. It will be noted that this curve very closely approximates the average condition at all times over about two minutes. In order that some idea may be gained of the effect of the differences in rates of infiltration found in these experiments, coefficients for the depth of infiltration formula corresponding to the maximum and minimum rate shown by the curves of figure have been worked out. These, as well as those for the mean value of y in the formula above, are as follows:

Values of y	Coefficients		
	a	b	c
Maximum	0.100	1.15	0.35
Mean	0.050	1.15	0.35
Minimum	0.027	1.00	0.20

During the 1935 season records were kept of the rate of advance of the irrigating head over some 40 different border strips for a total of 265 individual irrigations. These data have been grouped in Table 1 according to the slope of the border strips and the size of the irrigating head. The observations were made on two series of plots, one a variety trial of alfalfa and the other a series of clover and grass mixtures in a pasture trial. The border strips are 55 ft wide by 400 ft long. In Table 1 the fourth column headed "Time flowing" gives the time during which the water was allowed to flow onto the upper end of the strip. It will be noted that in all cases, this time is intermediate between the time required for the stream to advance 300 ft and 400 ft. The practice in border irrigation on the Umatilla field station is to permit the advancing stream to reach about four-fifths of the distance from the upper end of the border to the extreme lower end and then shut the water off. In most instances the border dikes are continued to the end of the plots and small dikes are thrown up along the foot of the strip. In this way whatever water reaches the lower end is ponded. An attempt is made to shut the water off at the right moment so that just enough water will reach the lower end of the plot to provide a satisfactory irrigation.

Unfortunately no attempt was made in these observations to determine the average depth of water over the border strip during irrigation. For that reason it has been necessary to make assumptions as to the depth of water in plotting curves from the formula for advance of stream given heretofore.

For convenience in this discussion and on the figures the values for the size of the irrigating head (Q) are given in second-feet. In the formula q must be in terms of cubic inches per minute to conform to the use of the inch and the minute in the infiltration data. Likewise width and length of border and the distance advanced by the stream (X) are given in feet rather than inches (x) as in the formula.

On Fig. 5 points showing the advance of the irrigation stream as observed with irrigating heads between 2 and 3 sec-ft and with different slopes, have been plotted. Com-

TABLE 1. RATE OF ADVANCE OF IRRIGATING STREAM DOWN BORDER STRIPS ON THE UMATILLA FIELD STATION

(Data grouped according to slope of border strip and size of irrigation stream)

No. of trials	Slope	Size of stream	Time flowing	Time required to advance 100 ft	200 ft	300 ft	400 ft
		sec-ft	min	min	min	min	min
6	0.0020	2.70	32.3	6.2	15.8	28.5	46.0
6	0.0020	3.62	27.3	5.5	13.2	23.5	38.2
5	0.0020	4.46	26.8	5.0	12.8	23.6	36.2
3	0.0020	5.40	22.0	4.3	10.7	19.7	29.7
12	0.0045	2.50	27.5	5.9	13.2	24.1	36.0
16	0.0042	3.45	31.7	7.4	18.0	27.7	36.4
30	0.0042	4.32	29.0	7.1	16.6	27.2	35.7
8	0.0042	5.40	22.6	5.5	12.9	21.0	30.0
27	0.0062	2.48	26.9	5.8	13.6	23.2	35.2
4	0.0065	3.77	21.2	5.2	10.8	18.2	26.2
7	0.0062	4.32	20.7	4.4	10.4	16.6	27.4
3	0.0060	5.40	18.0	4.7	9.3	16.3	24.3
39	0.0088	2.55	26.0	6.3	13.5	22.4	32.3
9	0.0088	3.71	17.7	3.3	7.8	14.4	21.3
7	0.0090	4.00	22.6	4.3	12.1	19.2	25.6
15	0.012	2.73	21.3	5.2	11.5	18.7	27.1
8	0.012	3.58	18.4	3.9	9.2	15.2	21.9
4	0.012	4.00	15.2	3.8	8.2	14.0	18.8
32	0.013	2.75	17.9	4.4	9.1	15.0	22.1
16	0.013	3.54	15.2	3.2	7.6	12.4	19.0
8	0.013	4.00	13.2	3.6	7.2	11.6	16.4

puted curves are shown for the same average irrigating head and with such values for c (depth of water on the soil surface) as made the curves most nearly fit the plotted data.

Fig. 6 shows the observed data for a slope of 0.012 and with different irrigation streams, together with the corresponding computed curves. Considering the irregularity of the front of the advancing stream, the difficulty of estimating the rate of advance in the field, and the variability of the rate of infiltration, it is believed that these curves fit as well as can be expected.

Discussion. Field experience has demonstrated that the border strips on the Umatilla field station might be longer if the larger heads are used, or that smaller heads must be used if satisfactory penetration is to be secured.

Fig. 7 has been plotted to explore the possibilities of longer runs or smaller streams. The infiltration data shown on Fig. 4 show that there is considerable difference in the rate of infiltration at different points on the station. Using both maximum and minimum values for the coefficients in the rate of infiltration formula as given above, depth of water on the soil surface, and irrigating streams; comparative curves of the advance of the border stream are shown on Fig. 7 for runs of 200 min.

The curves show that with the maximum rate of infiltration and a stream of 2.51 sec-ft, the limit of length of border is 325 ft, while with a stream of 5.4 sec-ft the borders might be 700 ft long. On the other hand, with the minimum rate of penetration the limits would be 1200 and 2600 ft for streams of 2.5 and 5.4 sec-ft, respectively. However, such long runs would require several hours and would result in excessive applications at the upper end of the borders. If the application was limited to about 4 in at the head ditch, the time would have to be limited to about 2 hr (with the minimum rate of infiltration) and the distance to which the streams would advance would be reduced to about 1000 and 2100 ft. That depth of water on the surface makes a great deal of difference in the time required, can be seen from these curves. For instance, with a depth of 0.5 in, such as might be found on a steep slope with little vegetation, it would take 2.5 sec-ft 15 min to advance 200 ft with the maximum rate of penetration, while with a depth of 1.5 in, which might easily be caused by a flat slope and heavy vegetation, it would take 26 min to make the same advance with the same rate of infiltration. Other streams and rates of infiltration show somewhat proportional results.

The coefficient a in the formula $y = at + b(1 - e^{-rt})$ represents the steady rate of infiltration after the first half hour or so. This is the rate used by Parker, Israelsen, and others in considering the problem. The formula for advance of the border strip as given by Israelsen is

$$t = 2.303 \frac{y}{p} \log \frac{q}{q - pA}$$

where $t =$ time since water started to advance, $y =$ depth of water on the soil surface (equivalent to c in this paper), $p =$ the rate of infiltration, and A the area covered. Converted into a form similar to the formula used in this paper this becomes

$$x = \frac{q}{aL} (1 - e^{-(at/c)})$$

Fig. 8 shows the results obtained by this formula and the one proposed herein. For comparison the observed data from Table 1 for $Q = 2.51$ and $S = 0.0045$ have been plotted. It is shown that the curve computed by means of the new formula (using a variable rate of infiltration) much more nearly agrees with the observed data than does the one computed by the Israelsen formula.

The rates of infiltration of different soil types vary greatly. Some, as the Ephrata loamy sand at the Umatilla field station, show a constant rate of infiltration after an hour or less. Others, as the Elsinore loam at Caldwell, Idaho, and Amity silty clay loam near Corvallis, Oregon, show a steadily decreasing rate, rapidly approaching zero. The form of the rate of advance curve will also vary greatly. It is believed that this method of approach will be a valuable aid in studying methods of application of water.

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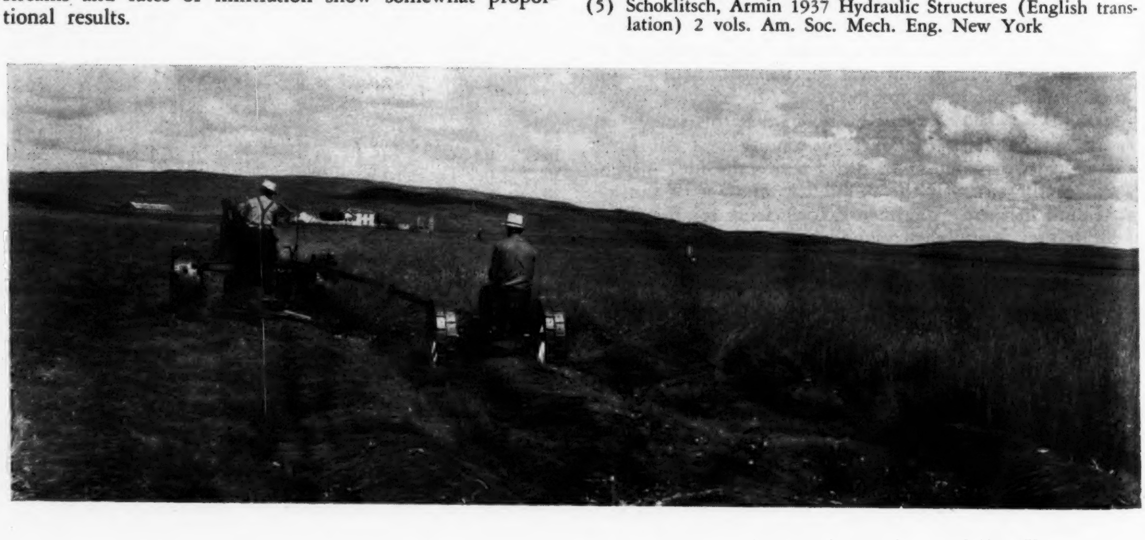


Meteorological Phenomena Affecting Low Temperatures on Experimental Peat Bog

By J. H. Neal

FOR A number of years it has been known that frosts may occur on peat bogs in any month of the year. Some local conditions affecting frosts are air drainage, depth of subdrainage, depth and compactness of the peat, dryness of the surface, and vegetation on the bog.

In 1927 the division of agricultural engineering of the Minnesota Agricultural Experiment Station started a project on a bog near Lake Minnetonka (Fig. 1) to determine the frequency and intensity of summer frosts.

At that time the bog was well suited to a study of summer frosts, as air drainage was inadequate, the bog being surrounded on three sides by high morainal ridges and on the south by dense tamrack timber and underbrush. Since 1930 the tamrack and underbrush have been cleared, resulting in good air drainage.

In 1927 maximum and minimum Tycos thermometers were set at temperature stations 3, 4, and 5. In 1928 two additional temperature stations were added, station 1 on the ridge north of the bog and station 2 at the north edge of the bog (Fig. 2). The thermometers were placed in shelters similar to those used by the U. S. Weather Bureau. Maximum and minimum temperatures were taken daily at the ground surface and one foot above the ground. Also a rain gage was set near station 1.

After three years' temperature records (1927 to 1929, inclusive) were obtained, an analysis was made of the weather conditions just before and during the time of a low minimum, less than 40 F (degrees Fahrenheit). The weather conditions considered included barometric pressure, humidity, rainfall, cloudiness, wind direction and velocity, and the various surface and air temperatures. With the exception of the rainfall and temperature records, which were kept at the experimental tract, the weather observations of the Chaska and Minneapolis stations of the U. S. Weather Bureau were also considered. Based on this analysis a paper, entitled "Temperatures of Peat Soils Relative to Summer Frost Control" (AGRICULTURAL ENGINEERING, vol. 12, nos. 3 and 4, 1931), discusses the factors affecting air temperatures on the experimental bog.

Journal series paper No. 1463 of the agricultural experiment station, University of Minnesota.

Author: Assistant professor of agricultural engineering, University of Minnesota. Mem. A.S.A.E.

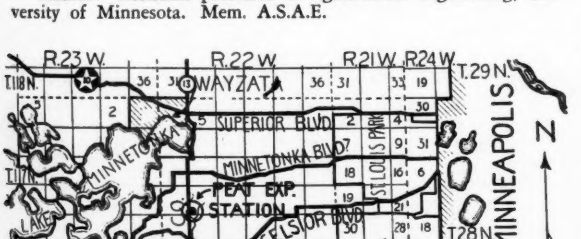


FIG. 1 MAP SHOWING LOCATION OF EXPERIMENTAL TRACT

Since the Chaska and Minneapolis weather stations are both located ten miles or more from the experimental bog, it was decided to check the results and conclusions set forth in the preliminary paper by taking all the weather data at the bog.

This was done during the growing season of 1930. The layout (Fig. 2) as shown was the same for 1930 as for 1928, except that additional weather instruments were set at temperature stations as follows: (a) Continuous recording psychrometers at stations 1 and 4; (b) recording anemometer and wind direction instruments at station 3, and (c) recording barograph at station 4. The sky condition was taken every two hours from 5 or 6 a.m. to 10 p.m. by the attendant at the bog. The maximum and minimum temperatures in air, at the surface, and one foot above the surface were taken daily at each of the five stations, as during the previous three seasons. A discussion of the 1930 records follows.

THE RELATION OF BAROMETRIC PRESSURE TO OTHER WEATHER TRENDS

Relation of Barometric Trends to Temperature Trends. Two types of barometric trends show on the barograph; the general trends extending over two to ten days, and the short sharper rise occurring each day, between 4 and 10 a.m. When the general trend was constant or downward, the short sharp rise was followed by a gradual drop, but when the general trend was upward, usually no drop occurred.

As a general rule, a rising temperature accompanied a constant or falling barometer, while a dropping temperature accompanied a constant or rising barometer. There was, however, considerable divergence from this rule (Table 1). For minimum temperature trends, 15 per cent of the cases, and for maximum temperature trends, 8.9 per cent of the cases of rising temperature, occurred with a rising barometer, while 9.2 and 5.7 per cent, respectively, of the cases of dropping temperatures occurred with a falling barometer.

The barometer pressures on days before and days of a low minimum (less than 40 F) were approximately equal, but appreciably higher than the average for the season, while the average barometric pressure for all other days was lower than the average for the season (Table 2).

On the 30 days of low minima, the barometric pressure was rising 13 times, constant 10 times, and falling 7 times. In all cases of the falling barometer, the pressure was above average (28.93) and in five of the seven cases it was above 29 (Tables 14 and 15).

TABLE 1. TEMPERATURE TRENDS RELATIVE TO BAROMETRIC TRENDS

Barometric trends	Minimum temperature trends: Rising, No. of cases	Rising, Per cent of total	Constant, No. of cases	Constant, Per cent of total	Dropping, No. of cases	Dropping, Per cent of total	Maximum temperature trends: Rising, No. of cases	Rising, Per cent of total	Constant, No. of cases	Constant, Per cent of total	Dropping, No. of cases	Dropping, Per cent of total
Rising	18	15.0	9	7.5	28	23.3	11	8.9	10	8.1	30	24.4
Constant	10	8.3	4	3.3	8	6.7	13	10.6	8	6.5	5	4.1
Falling	27	22.5	5	4.2	11	9.2	31	25.2	8	6.5	7	5.7
Total	55	45.8	18	15.0	47	39.2	55	44.7	26	21.1	42	34.2

Relation of Barometric Trends to Wind Directions. Table 3 gives a summary of the wind directions relative to barometric trends. For a considerable time the barometric pressure showed no appreciable trend either way, although there were small fluctuations up and down. At such times barometric pressures were considered constant. These periods of constant barometric pressure had a wide range as related to other weather phenomena. East and west winds occurred with about equal frequency under the different barometric pressure conditions. Approximately three-fourths of the time in which the wind was in a northerly direction, the barometric pressure was rising or constant, and a corresponding proportion of the time in which the wind was in a southerly direction, the barometric pressure was falling or constant.

The wind and barometric changes did not occur simultaneously but in general, the wind also changed within at least 24 hr before or after the barometric change, the average being only one hour after for a rising barometer, and 5 hr after for a falling barometer (Table 4).

The wind changed frequently without any appreciable change in the barometric pressure, and less frequently (7 times) the barometric pressure changed appreciably without a wind change.

Effect of Barometric Pressure on Sky Condition. Table 5 gives the relation of sky condition to barometric trends. In general a clear sky accompanied a rising and a cloudy sky a falling barometer. The partly cloudy days were usually transition days and were about equally divided between rising and falling barometric trends. In all but five cases, the barometric pressure change occurred first. When the barometer rose the sky usually changed within 24 hr, and, on an average, within 6 hr. When the barometer fell there was a greater lag in the sky change, up to a maximum of 48 hr, with an average of 16 hr (Table 6). The differences in the times for the sky to change accounts for the greater number of cloudy days with a rising barometer than clear days with a falling barometer (Table 5). There were 11 major barometric changes when the sky remained unchanged.

RELATION OF SKY CONDITION TO WIND DIRECTION

With a north or northwest wind the sky was usually clear, while with a south or southeast wind the sky was usually cloudy. With a northeast or southwest wind the sky was clear about half the time, and cloudy or partly cloudy the other half (Table 7). The sky condition did not change immediately after the wind changed but frequently followed within 24 hr. In two cases, it was 72 hr after the wind changed before the sky changed. As a rule, the change from clear to cloudy was slower than from cloudy to clear. The average times were, respectively, 14 and 10 hr (Table 8).

EFFECT OF WIND AND SKY CONDITION ON TEMPERATURES

As a rule, all days were considered as cloudy when the sky was overcast over 50 per cent of the time, although if the mornings were clear and the afternoons cloudy, the

TABLE 2. AVERAGES OF BAROMETRIC PRESSURES RELATIVE TO MINIMUM TEMPERATURES

Readings are the averages of those taken from the barograph at 6:47 p.m.

Item number		Barometric pressure
1	For season	28.93
2	For days before lows (less than 40 F.)	29.03
3	For days of low (less than 40 F.)	29.02
4	For other days not included under items 2 and 3	28.88

TABLE 3. WIND DIRECTIONS RELATIVE TO BAROMETRIC PRESSURE

Barometric trend	NW	N	NE	E	SE	S	SW	W	Total
	Per cent of total time								
Rising	13.5	2.6	2.1	0.8	2.6	1.4	3.3	3.3	29.6
Constant	7.9	3.6	2.1	0.6	5.8	3.2	3.8	1.2	28.2
Falling	7.6	2.4	3.8	0.8	13.1	6.2	6.8	2.0	42.2
Total	29.0	8.6	7.5	2.2	21.5	10.8	13.9	6.5	100.0

TABLE 4. WIND CHANGES RELATIVE TO BAROMETRIC CHANGES

Change in wind direction: From	To	Change from falling or constant to rising barometer, No.	Average number hours for wind to change	Change from rising or constant to falling barometer, No.	Average number hours for wind to change
Southerly	Northerly	19	1	0	–
Southerly	Southerly	0	–	1	–
Northerly	Southerly	0	–	18	5
Northerly	Northerly	3	–	3	–

TABLE 5. SKY CONDITION RELATIVE TO BAROMETRIC PRESSURE

Barometric trend	Clear, No. days	Clear, Per cent	Partly cloudy, No. days	Partly cloudy, Per cent	Cloudy, No. days	Cloudy, Per cent
Rising	32	26.0	15	12.2	13	10 6
Constant	8	6.5	8	6.5	7	5.7
Falling	8	6.5	14	11.4	18	14.6
Total	48	39.0	37	30.1	38	30.9

TABLE 6. SKY CONDITION RELATIVE TO BAROMETRIC CHANGES

Change in sky condition: From	To	Change from falling or constant to rising barometer, No.	Average number hours for sky to change	Change from rising or constant to falling barometer, No.	Average number hours for sky to change
Cloudy	Clear	15	6	1	–12
Cloudy	Cloudy	1	–	3	–
Clear	Clear	4	–	3	–
Clear	Cloudy	3	1	15	16

TABLE 7. RELATION OF WIND DIRECTION TO SKY CONDITION

(Per cent of total time, June to September)

Sky condition	Wind direction: East to north	North to west	West to south	South to east	Total
Clear	4.1	26.0	9.6	8.2	47.9
Partly cloudy	3.1	6.8	4.9	8.2	23.0
Cloudy	2.3	6.8	3.5	16.5	29.1
Total	9.5	39.6	18.0	32.9	100.0

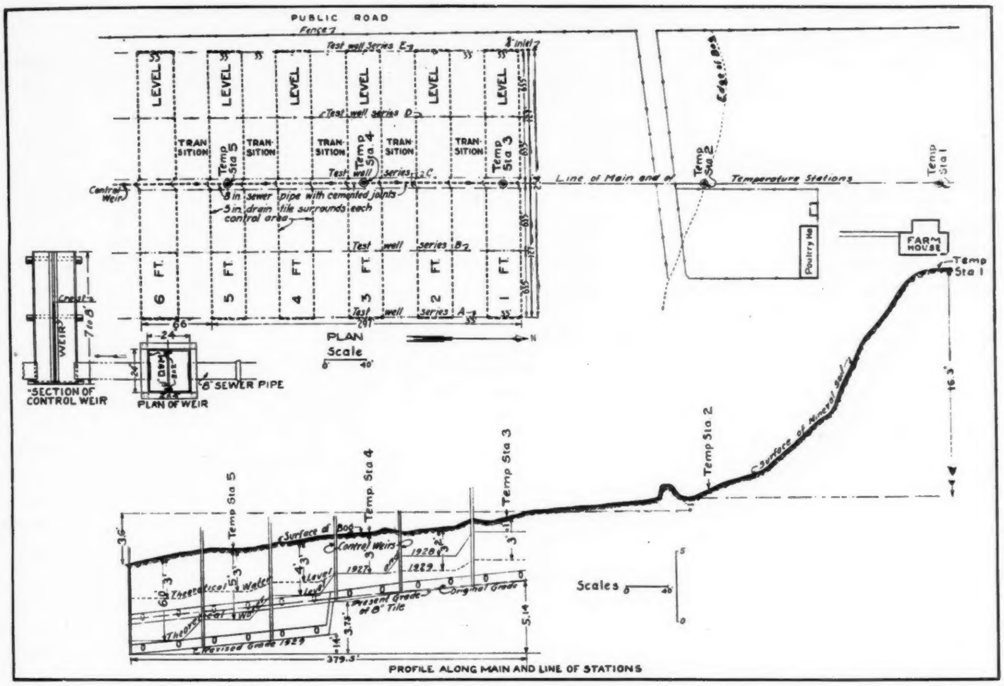


FIG. 2 PLAN OF EXPERIMENTAL TRACT

TABLE 8. SKY CONDITION RELATIVE TO WIND DIRECTION

Change in sky condition		Change from northerly to southerly wind	Average number hours for sky to change	Change from southerly to northerly wind	Average number hours for sky to change
From	To				
Clear	Cloudy	22	14	1	4
Clear	Clear	3	–	2	–
Cloudy	Clear			23	10
Cloudy	Cloudy	2	–	1	–

TABLE 9. WIND DIRECTION AT NIGHTS

	Total number days	Per cent
Observation season	125	100
Northerly wind 4-12 pm	69	55
Southerly wind 4-12 pm	56	45
Northerly wind 12-4 am	70	56
Southerly wind 12-4 am	55	44
Northerly wind evening before low minimum (less than 40 F)	22	73
Southerly wind evening before low minimum	8	27
Northerly wind morning of low minimum	22	73
Southerly wind morning of low minimum	8	27

minimum temperature was recorded for a clear day and the maximum temperature for a cloudy day, and vice versa for cloudy mornings and clear afternoons. Frequently the maximum temperature for partly cloudy days, classed as cloudy, would correspond to the maximum for clear days.

At night, when the minimum temperature occurred, the wind was in a northerly direction 55 per cent of the time. (Table 9). On nights when the temperature dropped below 40 F, the wind was in a northerly direction 73 per cent of the time. If the wind remained in a southerly direction, the danger of a frost was lessened, even when other conditions tended to frost. There was only one night (that of October 1) in which the wind was in a southerly direction when the temperature dropped below 32 F. (See discussion on page 277). During seven other nights the temperature dropped below 40 F when the wind was southerly.

The average maximum and minimum monthly temperatures for different weather conditions are given in Table 10. During June and September, days with northerly wind had both maximum and minimum temperatures appreciably below those for days with a southerly wind, while during July and August there was no appreciable difference in the average temperatures with differences in wind direction.

The average minimum temperature on cloudy nights was 10 deg higher than for clear nights. In all cases when the temperature dropped below 40 F, the sky was either clear the evening before or the morning of the low, and usually at both times. Two evenings were partly cloudy, followed by clear mornings, while two mornings were cloudy or partly cloudy following clear evenings. Apparently clouds have a greater stabilizing effect on temperature than does the wind.

EFFECT OF HUMIDITY ON TEMPERATURES

A study of the psychrometer records from the bog showed that, in spite of the wide range of humidity, except at times when precipitation occurred, there was a definite tendency for the humidity to change in a regular order throughout each day. The humidity at night usually was quite high. When the sun came up, it fell rapidly and continued to fall as long as the temperature rose. It was, therefore, lowest during the heat of the day. When the temperature began to fall, the humidity started to rise, but it usually remained quite low until sunset, when it rose rapidly for an hour or so. After the evening rise a rather stable value was reached from which there were only minor fluctuations. The tendency was, however, for a slow rise throughout the night.

TABLE 10. AVERAGE MAXIMUM AND MINIMUM TEMPERATURES FOR DIFFERENT CLIMATIC CONDITIONS

	June		July		August		September	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Month	80.2	50.8	87.9	53.5	88.7	49.5	76.2	42.1
Clear days	78.8	48.0	86.7	47.6	89.2	45.7	71.4	35.5
Cloudy days	81.8	54.3	89.0	60.6	88.2	54.8	81.1	49.6
Days with northerly wind	75.2	46.8	87.8	51.1	89.3	50.7	73.6	38.5
Days with southerly wind	84.1	54.2	88.0	57.2	87.8	47.6	80.7	52.1
Clear days with northerly wind	75.4	45.7	86.6	47.9	89.6	48.1	71.0	34.8
Clear days with southerly wind	83.0	51.7	86.7	46.0	87.7	39.5	72.3	38.6
Cloudy days with northerly wind	74.7	49.7	90.1	59.9	88.6	56.5	77.3	43.7
Cloudy days with southerly wind	84.9	55.9	88.5	61.0	87.9	53.3	85.5	60.2

TABLE 11. AVERAGE RELATIVE HUMIDITY RECORDED AT 6:47 p.m.

	Station No. 1 (on hill)				Station No. 4 (3-ft control)			
	June	July	Aug.	Sept.	June	July	Aug.	Sept.
Season	63	65	63	68	75	68	71	66
Days before a low minimum	64	59	56	70	75	62	71	65
Days before a frost	62	66	—	68	74	61	—	64
Excluding days before a low minimum	63	67	65	65	75	70	71	67
Clear days	64	64	61	68	73	64	71	64

TABLE 12. AVERAGE MINIMUM TEMPERATURES FOR THE DAY OF AND FIRST, SECOND, AND THIRD DAYS AFTER A RAIN, COMPARED TO OTHER DAYS

Time	Temperature reading
Season	49
Day of rain	55
First day after rain	51
Second day after rain	47
Third day after rain	48
Clear days	44

TABLE 13. RAINFALL AND ITS EFFECT ON AIR TEMPERATURES

Date of rain period	Rainfall, in	Number days to next rain	Number days to low temperature	Minimum temperature, deg F
June 3-4	2.23	8	4	31.8
" 12-13	0.91	3	0	40.5
" 16	0.14	6	2	37.2
" 21-22	1.13	2	2	46.0
" 24	0.62	6	0	46.0
" 30	0.12	3	1	36.0
July 3-4	1.09	4	3	45.4
" 8	0.15	15	6*	32.5
" 23	0.20	2	0	46.3
" 25	0.35	2	0	57.2
" 27	0.15	5	3	35.8
Aug. 1-3	0.91	24	3	51.3
" 27	0.20	5	2	39.6
Sept. 1	0.22	3	1	29.2
" 4	0.84	8	2	31.4
" 12	0.38	12	3	33.0
" 24-26	2.62	5	4	22.0

*Very evidently not affected by the rain.

While only general conclusions may be drawn from the records secured, it appears that, aside from the daily cycle, the humidity does not show any inclination to move in a cyclic manner. A heavy rain does not seem to be of much importance in changing the relative humidity except for a short time. However, several small showers coming along on consecutive days have a marked influence on the average. Any kind of a rain at any time may raise the relative humidity, temporarily, to above 90 per cent.

The average monthly relative humidity, as recorded at 6:47 p.m. is given in Table 11. (The time of 6:47 p.m. was used to correspond with the time used in the previous report mentioned.)

These data show that, at the time of the temperature lows, (4 to 6 a.m.) the humidity was, as a rule, about the same as it was at the corresponding time on clear days. That is, the humidity was not generally lower than usual when the low minimum temperatures occurred.

The relative humidity readings taken at 4 p.m., the time when the humidity was usually the lowest, gave no better indications of an approaching low temperature than did the 6:47 p.m. readings.

RAINFALL AND ITS RELATION TO TEMPERATURE TRENDS

It is a matter of common observation that the temperature during a rain is usually cool, but is seldom very cold and almost never really warm. So the findings that rainfall throughout an afternoon results in a low maximum temperature for the day, and that a rainy night seems to keep the minimum temperature from falling very low, appear reasonable. In many cases rains occur in, and often terminate, a warm spell.

There was a noticeable tendency for the temperature to drop following a rain. The average minimum temperature for the day of and the days following a rain are given in Table 12. The average temperature for the day of a rain was 6 deg above the average for the season and dropped to 2 deg below the season average on the second day after a rain. The average minimum temperature for the second day after a rain was higher than the average minimum for the clear days.

For the 17 rain periods of over one-tenth inch occurring during the four months (Table 13), nine were followed by marked temperature drops (below 40 F). The lowest temperature occurred on the first day after a rain 2 times, on the second day 3 times, on the third day 2 times, and on the fourth day 2 times. Four rains were followed by a frost within four days. All temperature drops occurring five or more days after a rain were due to other meteorological factors and not to the rain, as the temperature rose after the second or third day and then fell again.

Since 40 per cent of the days with low temperatures occurred five or more days after a rain and only a little over half of the rain periods were followed by marked temperature drops, it is evident that frosts cannot be predicted from

TABLE 14. WEATHER CONDITIONS DAY BEFORE AND MORNING OF FROSTS

Date 1930	Temperatures Day before Max *	Reading* 10 p.m.	Drop, max to 10 p.m.	Min	Barometric pressure,** evening before (10 p.m.)	Humidity Evening before (4 p.m.)	Morning of (4 a.m.)	Wind direction Evening before (10 p.m.)	Morning of (4 a.m.)	Wind velocity Evening before (10 p.m.)	Morning of (4 a.m.)	Sky condition Evening before (10 p.m.)	Morning of (4 a.m.)	No. days since rain
June 8	71.7	46.0	25.7	31.8	29.15	63.5	91.0	N	NW	0	0	clear	clear	4
July 14	75.7	55.0	20.7	32.5	29.13	41.0	100.0	NE	NW	3	0	pt. cloudy	clear	6
" 15	76.0	45.0	31.0	32.6	29.15	40.5	81.0	NW	NW	0	0	clear	clear	7
Sept. 2	69.0	39.5	29.5	29.2	29.07	47.0	81.0	NW	NW	0	0	clear	clear	1
" 3	78.8	48.0	30.8	32.3	29.07	32.0	86.0	NW	NW	0	0	clear	clear	2
" 4	76.9	41.5	35.4	28.8	29.12	33.0	81.0	NW	NW	0	1	clear	clear	3
" 6	71.3	43.0	28.3	31.4	28.94	44.0	81.0	NW	NW	0	0	clear	clear	1
" 18	72.6	40.0	32.6	31.1	*28.94	30.0	81.0	NW	NW	0	0	clear	clear	4
" 20	68.4	36.0	32.4	31.2	28.98	41.5	76.0	NW	SW	2	2	pt. cloudy	clear	6
" 22	76.8	41.5	35.3	31.0	28.76	26.5	81.0	NW	NW	0	0	clear	clear	10
" 25	83.2	41.5	41.7	30.5	28.80	44.5	76.5	NW	NW	0	0	clear	cloudy	1
" 28	52.8	36.5	16.3	32.1	28.89	57.0	76.5	NW	NW	3	4	clear	clear	2
" 29	56.7	31.0	25.7	22.6	28.97	39.0	100.0	NW	NW	0	0	clear	clear	3
" 30	60.7	31.0	29.7	22.0	29.14	38.5	100.0	NW	NW	0	0	clear	clear	4
Oct. 1	61.2	30.0	31.2	24.5	29.20	44.0	83.0	SW	SW	0	0	clear	pt. cloudy	5
Average	70.1	40.4	29.9	29.6	29.09	41.5	83.7			0.5	0.5			3.7

* Psychrometer 3-ft control

**The barometric pressure at 4 a.m. is nearly the same as at 10 p.m.

rain periods unless other meteorological factors are also considered.

METEOROLOGICAL PHENOMENA OCCURRING ON THE DAY BEFORE AND THE DAY OF A LOW TEMPERATURE

The maximum temperature for the day before a frost was always low, (below 85 F), and the drop from the maximum to the temperature reading at 10 p.m. averaged 30 deg (Table 14). This drop was 8 deg more than the average drop for other days. When the temperature at 10 p.m. was 55 F or less, and other conditions were favorable, a frost was likely to occur. Out of 41 times, from June to September inclusive, when the temperature dropped to 55 F or less by 10 p.m., there were 23 times when all weather conditions indicated extremely low temperatures. Frosts occurred 15 times. That is, the predictions were about two-thirds correct. The other 18 times when the temperature dropped to 55 F bv 10 p.m., other weather conditions were not favorable for frosts. Either it was cloudy, the soil wet from recent rains, the wind from the south, the wind moving at a velocity above 5 mph, or a combination of two or more of these factors.

The usual weather conditions occurring on the day before a low temperature were a low maximum (less than 85 F) and dropping to 55 F or less by 10 p.m., a high barometric pressure (usually rising), a clear sky and a northerly wind with a low velocity (less than 5 mph) (Tables 14 and 15). Out of the 15 days when frosts occurred, all the above conditions prevailed 14 times. On one occasion, late in the season, a frost occurred when the wind was in the southwest, but all other weather conditions were favorable for a frost. There had been frosts for the three nights previous, and the maximum temperature the day before was only 61 F.

The weather conditions on the day of the frost, except for the early morning hours, had no bearing on the frost occurrence. In case the wind changed from northerly to southerly, or the sky changed from clear to cloudy shortly after midnight, frosts were usually warded off, although the conditions the evening before may have indicated a frost. Such a change occurred several times during the season. On September 20 a frost occurred after the wind had changed from the northwest to the southwest. The temperature had dropped to 36 F by 10 p.m., before the wind had changed.

Although each particular bog will have certain local conditions affecting the temperature, it is quite likely that the probability of frosts can be predicted along lines herein discussed with a fair degree of reliability after these local conditions are known.

TABLE 15. WEATHER CONDITIONS DAY BEFORE AND MORNING OF LOW TEMPERATURE BUT NO FROST

Date 1930	Temperatures Day before Max *	Reading* 10 p.m.	Drop, max to 10 p.m.	Min	Barometric pressure,** evening before (10 p.m.)	Humidity Evening before (4 p.m.)	Morning of (4 p.m.)	Wind direction Evening before (10 p.m.)	Morning of (4 a.m.)	Wind velocity Evening before (10 p.m.)	Morning of (4 a.m.)	Sky condition Evening before (10 p.m.)	Morning of (4 a.m.)	No. days since rain
June 9	76.1			37.0	29.12	51.0	88.0	SW	SW	0	0	clear	clear	5
" 18	66.3	50.5	15.8	37.2	28.86	62.5	84.5	N	N	0	0	"	"	2
July 1	74.2	53.0	21.2	36.0	28.97	65.0	83.0	NW	NW	1	0	"	"	[illegible]
" 2	77.6	51.0	26.6	39.4	28.98	58.0	88.5	SW	SW	0	0	"	"	2
" 30	84.8	50.0	34.8	35.8	29.16	33.5	83.0	NW	NW	0	0	"	"	3
" 31	82.5	49.0	33.5	37.3	29.15	35.5	96.0	NW	NW	0	0	"	"	4
Aug. 10	83.7	60.0	23.7	33.3	29.08	41.0	92.0	N	NE	0	0	"	"	7
" 11	77.6	45.0	32.6	34.1	29.15	50.0	100.0	NW	NW	0	0	"	"	8
" 18	86.1	62.5	23.6	39.7	29.01	42.5	79.3	SE	NW	1	2	"	"	15
" 21	85.2	54.0	31.2	37.0	29.18	43.0	83.0	SE	SW	0	0	"	"	18
" 22	85.2	50.0	35.2	39.0	29.18	36.5	84.5	SE	SE	0	0	"	"	19
" 23	86.8	51.0	35.8	38.5	29.14	39.0	93.3	SW	SW	0	0	"	"	20
" 29	82.4	47.5	34.9	39.6	28.99	40.8	88.0	NW	NW	0	0	"	"	2
Sept. 8	73.1	45.0	28.1	36.6	29.00	52.5	83.0	SW	SW	0	0	"	"	4
" 15	78.0	55.0	23.0	33.0	28.70	68.5	86.5	NW	NW	1	0	"	"	3
Average	80.0	51.7	28.6	36.9	29.04	48.0	87.5			0.25	0.2			7.3

* Psychrometer 3-ft control

**The barometric pressure at 4 a.m. is nearly the same as at 10 p.m.

Making Farm Crops More Available for Industry

By L. F. Livingston

TO OBTAIN the results expressed in the wording of the title the farmer must produce the crop wanted, and in the right manner for industry. Industry must have the correct process and the right plant in the right location, to use the crop. My title covers both, and rightly, I think, groups the farmer and the industrialist together as coworkers in a common sense.

The only long-time, fundamental, lasting way to make farm crops more available for industry is through research, analysis, review, and more research. Research at the farm for the crops that industry can use, research at the factory for processes which will convert the crops that the farmer can best grow, research that is undertaken with resolution and pursued with patience.

In the past we have had what seems like a great deal of research of this kind. In the future, we must have much more. We do not wish to disparage the accomplishments of the past. They have given us materials now in common daily use far better in appearance and utility than could have been dreamed of fifty years ago. They have reduced the cost of these materials until they are cheaper than the natural products which they have replaced. They have made possible more exact treatment of disease, more effective safeguarding of health, more efficient production of the necessities of life. In addition, they have put millions of farm acres to work producing factory raw materials. They have reduced farm wastes in every department of agriculture. They are saving our natural resources for future generations.

The job of experiment station men has been to produce more and better crops. Only a small amount of their time has been spent on the utilization of the crop. The ratio should be increased. Further agricultural engineering research leading to chemurgic efficiency is vital.

All plant life produces cellulose. The question is, which will produce the highest quality, the greatest quantity at the lowest cost, delivered at the factory. The work of the plant specialist is valueless until the agricultural engineer delivers it to the factory at the lowest possible cost.

CONSUMERS' WANTS AS A BASIS FOR RESEARCH

What are some of the problems which are to be met by the research scientist? Let us look at the picture from the viewpoint of the consumer. The consumer wants, needs, and should have better and cheaper houses in which to live. He wants better and cheaper clothing to wear; better and cheaper food to eat. He needs better prevention and control of disease, and he wants more time and money for pleasures and luxuries. Given these things, society will be on a higher plane. Wealth, or that which money can buy, will be more available to all, and human welfare will have been immeasurably advanced. There can be materials developed which are adapted to every type of building and every local condition. There can be better and more efficient means of creating heat and energy. There can be better ways of treating illness than the springtime dosing with sulphur and molasses.

We can't hurry the research scientist. The nature of his work prohibits an atmosphere of competition. Premature deductions and announcements are frequently costly. Rarely is research successful except through patient, sustained work over a period of years. Research demands long-term planning and long-term financing; financing which does not fluctuate with the sales charts.

CAPITAL NEEDED TO INTRODUCE NEW PRODUCTS

Regardless of the successes of science in developing new products, they cannot be introduced to the public in appreciable volume without large preliminary expenditures. To make substantial changes in our lives and to create substantially increased markets for farm goods, research must have patient capital behind it, capital that is willing to take a long risk. Capital of this kind has a tendency to go into hiding when assailed by strange apparitions and sounds. It can only be lured out of the cracked teapot on the top shelf by a feeling that the undertaking that calls it is sound and free from unreasonable outside attacks. Let us hope that soon such conditions will again exist, and that the research so vital to present-day advance can go on unhampered by fears and cries of alarm.

Another thing that has a bearing on the development of manufacturing units to utilize farm products is the local fiscal policy holding in specified areas. Late years have seen considerable shifting of industry from one location to another, due to unfriendly tax situations.

Summing this up, in order to make farm crops more available for industry, and industry more available for farm crops, these things must be remembered:

1 Farming is a business, not merely a vocation, and it must be treated as any other business.

2 Research, with special emphasis on chemurgic research, is the main answer to the subject, but agricultural-engineering research, and what I like to call "pilot plant research," must keep pace with other departments in order to secure chemurgic success.

3 Research has scarcely scratched the surface of the possibilities even now evident to those informed on the subject.

4 Capital must have confidence in the future, to be willing to risk investing in long-term research.

5 States expecting to benefit from chemurgic factories should study their fiscal and tax conditions and compare them with their neighbors.

I am an optimist, but I believe the way to be an effective optimist is to face the facts as they are with a view to revising where revision is due. The chemurgic idea is bound to build a future, the details of which we can only guess at the present time. I believe that the five points which I have outlined present a foundation for the rapid building of a future which is stable and sound.

An address before the Fourth Annual Conference of Agriculture, Science, and Industry, sponsored by the National Farm Chemurgic Council, at Omaha, Neb., April 25 to 27, 1938. (EDITOR'S NOTE: This paper appears here in slightly condensed form.)

Author: Manager, agricultural extension division, E. I. du Pont de Nemours and Co. Fellow A.S.A.E.

What Agricultural Engineers Are Doing

FROM THE U. S. BUREAU OF AGRICULTURAL ENGINEERING

R. D. MARSDEN left Washington May 5 to spend several weeks at the hydraulic laboratory, University of Iowa, analyzing research investigations and experimental work on the hydraulic jump on sloping aprons, and runoff studies of the Ralston Creek watershed. The extensive runoff data compiled from the Ralston Creek watershed studies cover a continuous period of many years and a comprehensive analysis of the work is to be made. A report on estimating runoff under varying conditions will be made available upon final compilation of the data thus far collected on this watershed.

* * *

J. C. Cotton visited the five CCC drainage camps in Delaware and Maryland on May 3 to 7 to inspect the research investigations on the flow of water in drainage channels. Several slope courses were established during 1936 to determine the value of the coefficient *n* in Kutter's and Manning's formulas for the flow of water in open channels under different conditions of ditch maintenance. The data obtained by field measurements are being analyzed in the Washington office.

* * *

F. E. Staebner and J. R. Cowand returned to Washington May 6 from Willard, North Carolina, where studies are being made to determine the value of supplemental irrigation in growing strawberries. The data collected during the 1938 crop season are now being analyzed.

* * *

During April, the central district drainage camps report the following work accomplishments: 4,836,736 square yards of clearing; 1,119,448 cubic yards of excavation and embankment; 28,181 lineal feet of tile reconditioning; 14,370 man-days of miscellaneous work. The local drainage enterprises cooperated to the extent of $65,937.

* * *

At the request of Dr. G. E. P. Smith, chairman of a committee of nine appointed by the governor of Arizona to study the situation as to underground waters in Arizona and their legal control, Wells A. Hutchins met with the committee at Phoenix at their first session. A possible outcome of the committee's work is recommended legislation to cope with what all agree is a difficult situation in that state, resulting from court decisions on ground waters.

* * *

Leslie Bowen made a trip to the Pineridge Indian Reservation in western South Dakota, upon request of representatives of the U. S. Indian Service, and gave a talk on the fundamentals of irrigation to a convention of teachers and project leaders at the reservation. It is planned to encourage the Indian population in the growing of subsistence gardens under irrigation. Most of the garden tracts are in the narrow valleys along the streams, and from the streams the water is to be taken either by gravity or by pumping. Small earth dams, some of which have already been constructed, are to provide storage wherever possible.

* * *

Contributions Invited

All public service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

Authors

W. T. Ackerman and G. M. Foulkrod are among the authors of New Hampshire Agricultural Experiment Station Bulletin 303, on "Electric Brooding of Chicks, II Heat Requirements."

F. C. Fenton and H. E. Stover are authors of Kansas State College Extension Bulletin 63, revised, entitled "Wiring the Farmstead."

B. A. Jennings is author of Cornell Extension Bulletin 385, on "Repairing the Spring-Tooth Harrow."

A. A. Young investigated the possibilities of carrying on studies of evaporation from pans in comparison with actual lake losses at two widely separated points in southern California—Lake Elsinore in the Santa Ana Mountains and Silver Lake in the Mojave Desert, both of which offer unusual opportunities to check reduction coefficients for the Weather Bureau pan and the new screen-covered pan. Each lake is 6 to 7 miles long and about 2 miles wide, and apparently evaporation is the only means of lowering the water surface of each. The Silver Lake area is ordinarily entirely dry but owing to unusually heavy rains in March, the Mojave River, which normally sinks into the desert sands in the vicinity of Barstow, extended itself an additional 50 miles to end in the desert depression called Silver Lake, which now has neither inflow nor outflow. Test pits in the lake bottom when it was dry showed silt deposits in excess of 3 feet, which would prevent any considerable amount of seepage. The water is not over 7 feet deep at the lowest point, and will probably dry up in 12 to 16 months. Lake Elsinore has a small inflow from San Jacinto River, which is measured by the Geological Survey at a gaging station above the mouth of the river. The inflow is sufficient to maintain the lake for some time.

* * *

R. L. Parshall and Carl Rohwer built and tested the model of an instrument to measure small differences in head by taking advantage of the fact that for low heads of the order of 0.001 foot the resulting velocity is several hundred times greater numerically than the head that produces it. The preliminary tests of this device indicate that it will be possible to measure small heads in this way.

* * *

Under the snow survey and irrigation water supply forecasting project, J. C. Marr, R. A. Work, and L. T. Jessup prepared and distributed reports of monthly observations on the Columbia River Basin in Idaho, Oregon, and Washington; R. L. Parshall and Carl Rohwer for the Rio Grande, Colorado, and Missouri and Arkansas River basins; and George D. Clyde for the Utah area. Several conferences were held to plan for the forecast of water supply conditions for the coming irrigation season. R. L. Parshall reports that a series of four monthly pictures of a section of the back range of mountains at the head of the Poudre River is now available for a preliminary study of the correlation of snow cover as indicated by these pictures and the stream flow from that area. This study will be developed along the lines worked out by H. L. Potts, engineer of the Denver Municipal Water Board.

* * *

A. T. Mitchelson and Dean C. Muckel inspected damage done to water-spreading areas in southern California by the floods of early March. Estimates were made of equipment needed to replace Parshall flumes, recorders, etc, that had been used on the Bureau's experimental plots and that had been lost or damaged during the floods. Messrs. Mitchelson, Muckel and Harry F. Blaney also inspected irrigation work in Coachella, Palo Verde, and Imperial valleys, and spreading systems on Whitewater and Santa Ana rivers.

* * *

W. P. Green has completed a series of calorimeter tests on various fruits and vegetables at Arlington Farm. The tests have included runs 45 and 50 degrees Fahrenheit. At these temperatures the results show that the amount of heat generated by respiration of these products can be estimated with reasonable accuracy from the amount of CO_2 generated.

* * *

A. H. Senner has been working on air atomizing oil burners for orchard heating. Several heaters have been constructed and two are being shipped to California for further testing.

* * *

A wheat drier embodying the principle of first heating the wheat then blowing air through it has been constructed by C. F. Kelly. The drier is being tested at Arlington Farm.

* * *

Two 3-room experimental houses have been erected in the test house group at Athens, Ga., to measure the results of changing various details of construction one at a time. There are six one-room houses of various types of construction also under study.

* * *

Germination stand counts are being made on sugar beet plantings put in with the experimental single seedball planter built at Davis, Calif., and with single-seed planters being developed by John Deere and the Ventura Manufacturing Company. Because of the lateness of the planting season in California and the consequent limited moisture, germination stands are spotted and some of the fields *(Continued on page 288)*

NEWS

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

PUBLIC FORUM PLAN LAUNCHED SUCCESSFULLY

JUDGING by the attendance, by the character of the contributions, by the purposefulness of the discussion, and by the sincerity of the congratulations of those present, the plan of a series of public forums of American Engineering Council was launched successfully May 13 at the Engineers' Club of Philadelphia. More than 150 representative engineers, economists, industrialists, and representatives of the public attended the afternoon and evening sessions.

The groundwork for the discussion of the topic, "Employment and the Engineers Relation to It," was laid by a constructive contribution by Dr. Leo Wolman, economist of the National Bureau of Economic Research and professor of economics, Columbia University, on "Labor Policy and Prospects for Employment." The opening statement of Dr. Wolman was preceded by greetings from the engineers of Philadelphia, by Charles E. Bonine, president of the Engineers' Club of Philadelphia, which acted as host to the guests of the forum; and a statement of the plan and purpose of the forums of American Engineering Council by Frederick A. Allner, vice-president of the Pennsylvania Water and Power Company of Baltimore, and chairman of the A.E.C. Public Affairs Committee under whose auspices the forum was held.

Dr. Wolman's opening statement was followed by an appeal by Leonard J. Fletcher, the representative of the A.S.A.E. on American Engineering Council, to the engineers present to find ways and means of making the average voter conscious of the contributions of technology to employment. He supplemented his general statement with factual illustrations drawn from his own experience and from quoted authorities.

The evening session was presided over by Dr. William McClellan, president of American Engineering Council. The discussion was preceded by two prepared contributions: one, "Technology and Competition" by Stephen DuBrul, economist of the General Motors Corporation of Detroit; and the second, "The Relation of Technology to Finance" by William J. Kelly, president, Machinery and Allied Products Institute, and president, Arthur J. O'Leary and Sons, Chicago.

Dr. William McClellan expressed the appreciation of American Engineering Council to each of the speakers and to the Philadelphia Engineers' Club for their hospitality. He summarized some of the major points made during the afternoon and evening as follows:

1 That Dr. Wolman had indicated that there had been a steady growth of permanent unemployment during the last 30 years throughout the countries where statistics were available and that technology was only one factor in the problem of unemployment.

2 That unemployment in the statistical series presented by Dr. Wolman seemed far greater in those industries which had made the least technological advance.

3 That governments, both in the United States and abroad, had been in business over many years but that the social adjustments brought about by social legislation in the earlier years had been absorbed by business and industry without great dislocation, whereas, since the year 1920 there had come a period of social adjustment which had been put into effect too fast for industry to absorb it, with consequent dislocation in the more normal procedures of business recovery.

4 A number of speakers emphasized by practical illustrations the need of "putting the pump in order" before trying to prime it. Government spending for public works was stated to be only one factor in recovery and might be a minor factor if other parts of industrial enterprise were badly out of order.

5 On the financial side, Mr. Kelly presented the argument that savings must be looked upon as a basis for capital improvements, that no great change can come about in the capital goods industries without expenditures for capital goods and expenditures for capital goods rest upon the people's savings which make possible capital creation.

Mr. DuBrul startled his audience by stating that the labor content in man-weeks for an automobile was the same now as it was ten years ago; in other words, a Chevrolet today has the same number of labor-hours that a Buick had ten years ago, so that the labor content per dollar in a Chevrolet is the same as it was ten years ago. This apparent paradox he explained by stating that there was more in a car today relative to the quality of the car ten years ago, and the difference had been made possible by technological improvements in materials, in parts, in methods and in machinery.

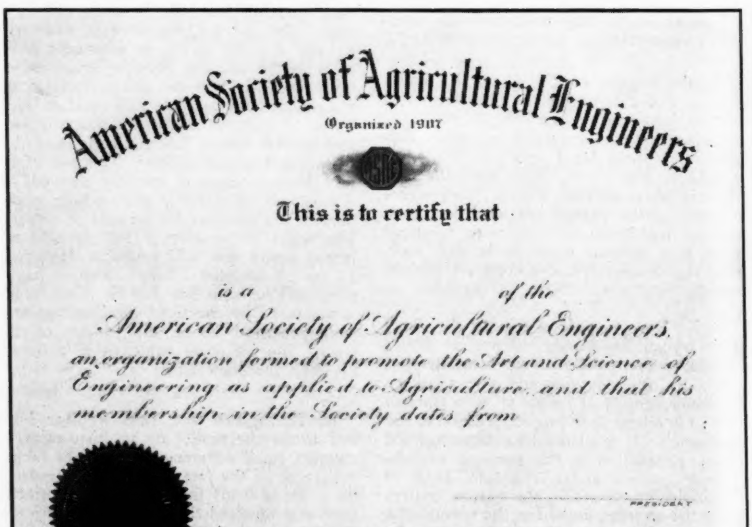
All speakers agreed that the problem was complex but that there was proof that, in the long run, technological progress had proved the basis for increased employment. Much of the discussion of the evening revolved around (Continued on page 284)

Membership Certificates Available

A.S.A.E. membership certificates in the form illustrated here have been made available by the Society. The certificate form was approved by the Council some time ago, but sale was held up awaiting final approval of the revised constitution, preparation of the certificates, and completion of the mechanics of handling orders from members.

The full-sized certificate measures 10¾ by 14 inches and is printed on heavy parchment stock suitable for framing. A blue background is provided for the embossed emblem on the certificate for Fellows and Members, and a red background on the emblem of the certificate for Junior Members and Associates. Hand lettering will be used in inserting the individual member's name, grade, and date of affiliation with the Society. The certificate will be signed by the President and Secretary, and will bear the official seal of the Society.

Certificates will be supplied to paid-up members of the Society on order to the Society headquarters at $1.50 each. Members are requested to specify, in ordering, the exact spelling of their names as it is desired that they appear on the certificate.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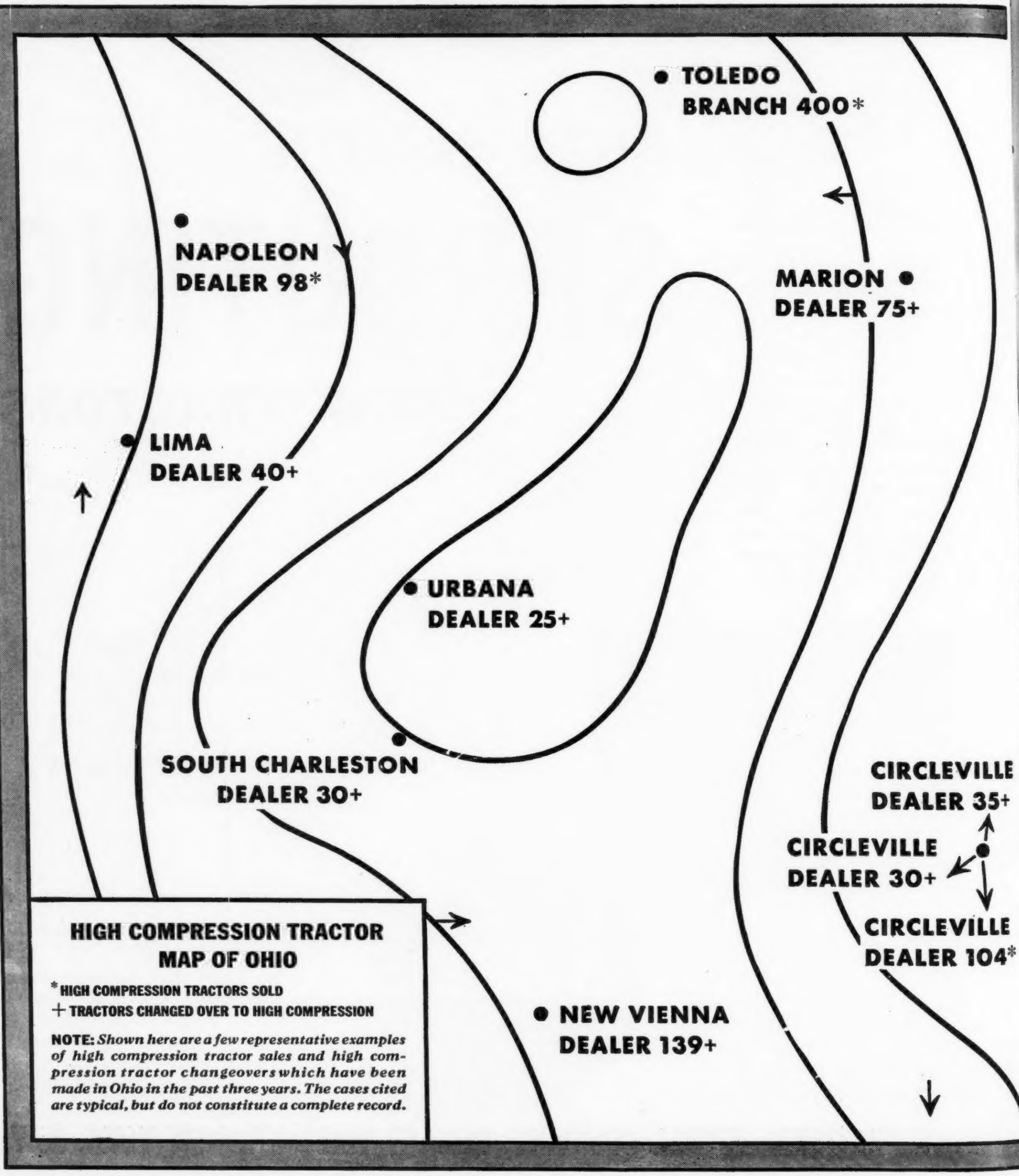
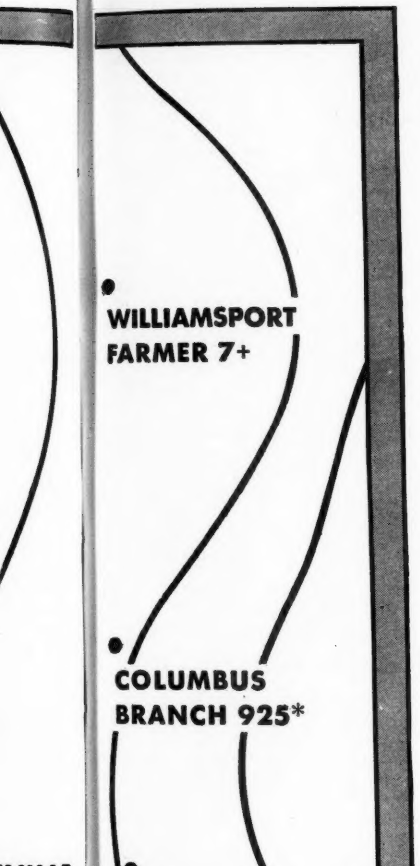


re **Area** ***moving your way***



It all started three years ago in the northern part of Ohio. There, in the little town of Napoleon, Elmer Niebel made a decision that affects the profits of every tractor dealer

THAT HIGH PRESSURE AREA sweeping over Ohio isn't wind. It's the march of another great force that has gathered strength and is now sweeping the country. Study the map closely. It pictures the progress of an idea that was brand new only three years ago—high compression for tractors.

It was three years ago that Elmer Niebel of Napoleon, Ohio, bought the first high compression tractor. Since that day one company in Columbus alone has sold 925 high compression tractors. A single branch in Toledo sold 400 last spring. At Marion a dealer has completed 75 changeover jobs in a year and a half. In New Vienna another dealer has made 139 changeovers to high compression since August 1937. In two years a Circleville dealer has hung up 104 sales.

And so it goes, not only in Ohio but throughout the country. In town after town progressive dealers are successfully selling high compression tractors—not just because they are the new thing and more profitable to sell, but because they fill the need of farmers for more power and greater economy in tractors.

If you are not now selling high compression tractors, or if you do not know how easy it is to high compression an old tractor, get the story from your manufacturer or blockman. Find out the high compression models your company makes, the "altitude" pistons or high compression cylinder heads necessary to change over low compression tractors. Join the march of high compression and serve your customers and yourself better by offering better tractors for better farming. Ethyl Gasoline Corporation, New York, N. Y., manufacturer of anti-knock fluids used by oil companies to improve gasolines.

To Sell More Tractors **DEMONSTRATE HIGH COMPRESSION**

Washington News Letter

(Continued from page 280)

other factors in the present day situation outside of technology, including overextension of social legislation, interference with business investment on a speculative basis, and so on. It was stated that engineers shared with the other professions the need of presenting factual information to those in legislative halls not only in the field of technology but in the related fields of economics where the work of the engineer and of the economist and the social scientist meet.

RADIO DISCUSSION OF MAPPING

Topographic mapping of the United States and the Hayden-Ickes Bill were discussed by Alexander Schreiber and J. C. Penn of the Armour Institute of Technology at 7:00 p.m., March 19, 1938 through Station W.C.F.L. at Chicago. It was the second in a series of educational broadcasts sponsored by the Armour Institute of Technology and relating to the field of civil engineering. Prof. Penn and radio interpreter Schreiber made an interesting presentation of the objectives of the Hayden-Ickes Bill now pending before Congress for completing the mapping of this country.

AEC does not have a record of the radio listeners' responses but the practical need for accurate maps, the extent of the unmapped portion of the United States and mapping procedure under the U. S. Coast and Geodetic Survey, the U. S. Geological Survey, and other mapping agencies were clearly outlined, along with a number of the more important uses for maps and basic survey data. In indicating the probable cost of completing the essential maps of the country, Prof. Penn cautioned the public against the use of maps hurriedly made by aerial photography where there is need for accuracy.

In concluding his brief but illuminating comments on the Hayden-Ickes Bill, interpreter Schreiber stated that "while the general public cannot understand a topographic map any more than it can a cardiograph, such a program is definitely of public interest since the public, in the last analysis, is forced to pay the bills. Therefore, it is the duty of engineers and surveyors to make their needs for maps, and the needs of the country for accurate geodetic and topographic information, known so that the Hayden-Ickes or a similar plan may be carried out!"

ACTIONS BY U. S. CHAMBER OF COMMERCE

"National Progress through the American Business System" was the theme of the twenty-sixth annual meeting of the Chamber of Commerce of the United States, held this month in Washington, D. C. From the opening address by president George H. Davis to the conclusion of the meeting, much of the discussion had to do with vital subjects of equal interest to engineers and engineering organizations. In firm but conciliatory tones, the business men of the country analyzed their problems and proposed remedies, including both public and private endeavor, in which it was frankly admitted that business must take the lead by telling the public the true story of business and the facts regarding the fundamentals of the American business system.

After emphasizing the facts that business in the United States is a system of organized individual enterprise and that it is in the hands of the people who pass judgment upon it daily, president Davis cautioned that everyone cannot have everything he wants because the promulgation of selfish motives in business and industry leads to chaos. "If the American system is to endure, it must be contemplated as a whole and not with an eye to benefiting one class or group to the detriment of other classes or groups of our people. The care of our business is voluntary cooperation. Its greatest menace is class antagonism."

Of particular interest to engineers was an address by Mr. Edward P. Palmer, president of the Associated General Contractors of America, in which Mr. Palmer expressed the opinion that "there is no industry so dependent upon confidence as construction. The confidence necessary to our continued existence will return when buyers and inventors, large and small, are convinced of four fundamental things: First, that the power of taxation is to be used for the purpose of raising revenue and that its use as a compulsory measure has been definitely and permanently abandoned; second, that the integrity of the nation's financial and credit structure be jealously guarded; third, that government has retired from competition with its citizens in the field of business; fourth, that legislation affecting the employer and employee relationship will be revised so as to promote operation rather than conflict and that all branches of the government and its agencies are guided by justice 'with malice toward none.' When these few reforms are accomplished, construction's brightest prospects will become realities."

MEETING OF AEC EXECUTIVE COMMITTEE

The spring meeting of the Executive Committee of American Engineering Council was held in Philadelphia on the morning of May 13, preceding the first Forum. The quarterly report of the executive secretary, the treasurer and announcement of committees were received and approved. These will be distributed to all members of the Assembly.

The Executive Committee discussed and acted upon a number of public questions and projects. It was voted to record by resolution the approval of the appointment of a special Congressional Committee to conduct a fact-finding investigation of the TVA.

It was voted to empower the president of Council to appoint a special committee representing the profession as a whole, to cooperate with the staff of the Army and Navy on questions of national defense. This proposal was in accordance with the recommendation voted by the Assembly at the January meeting.

Favorable consideration was given to a proposal to sponsor a special inquiry into the status of young engineers under the general direction of the AEC Engineering and Allied Technical Societies Committee on Engineers' Economic Status, of which J. S. Dodds is chairman, the work to be conducted by the Personnel Research Federation with funds supplied by The Engineering Foundation.

A factual study of the relation of patents to monopoly, proposed by Chairman R. S. McBride of the AEC Patents Committee was approved, provided the budget for the purpose could be obtained from sources outside of our present member organizations.

The executive secretary announced the election of the Engineers Club of Memphis and the Structural Engineers Association of California as members of American Engineering Council, bringing the total members of Council up to fifty-two, the largest in its history.

The Executive Committee, after reviewing many comments of approval on the new form of the Bulletin, instructed the executive secretary to inquire into the cost of printing the Bulletin in quantity so it might be made available to state and local societies for redistribution by them to their members. General approval was expressed of the appearance and content of the Bulletin.

The Executive Committee received many expressions of approval of the proposed series of public forums to be conducted by American Engineering Council. Consideration was given to several suggestions for extending and developing the forum idea. A number of local organizations have expressed interest in developing the public forums and it was the consensus of opinion of the Executive Committee that as soon as Council had had more experience in developing the series of major forums it could perform a useful service by the preparation of a handbook on "how to run a forum" for the use of local committees and chairmen.

Plans were also discussed for finding ways and means of putting the results of the series of forums in printed form.

The Public Affairs Committee, under whose auspices the forums are being directed, will be particularly glad to receive suggestions and subjects for future forums.

British Agricultural Engineers Organize

WORD has been received that at a recent meeting of agricultural engineers in London it was unanimously voted to proceed with the organization of an Institution of British Agricultural Engineers.

One objective of the Institution is to be the advancement of agricultural engineering education in Great Britain to compare with standards of training in this field available in other countries, and to provide British trained agricultural engineers for British agricultural engineering positions.

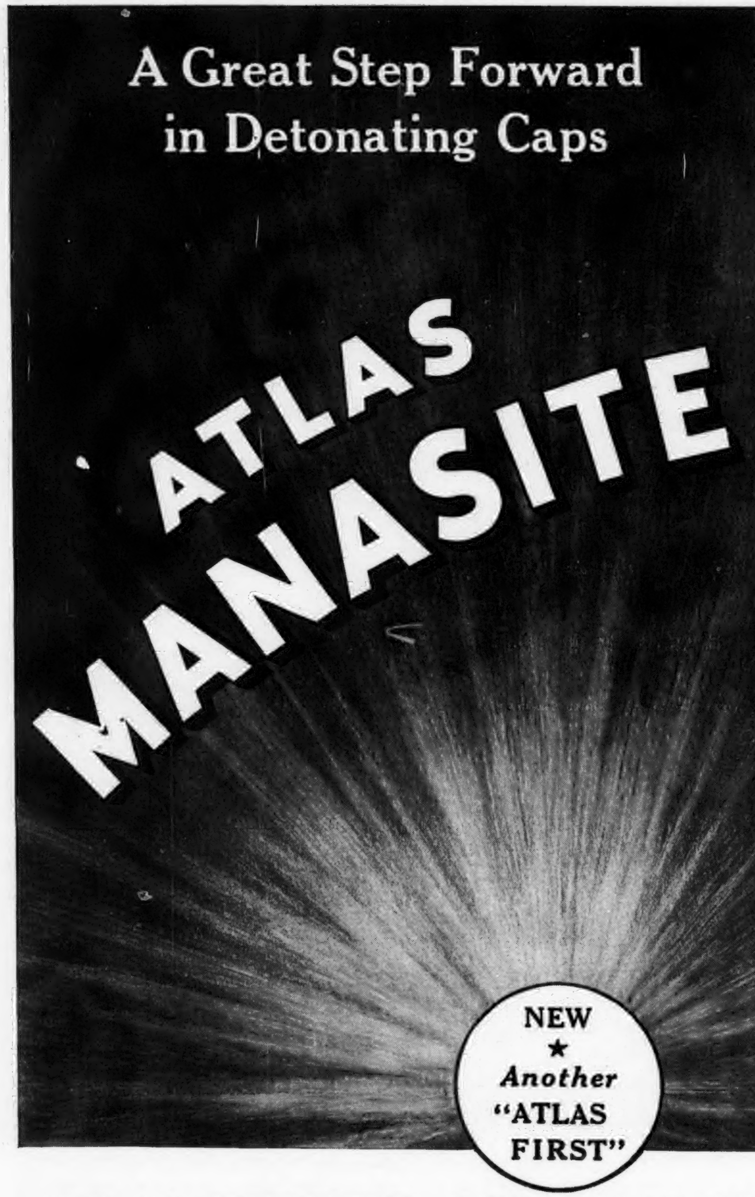
Another stated objective is to investigate "the mechanical needs of the farmer so that research and manufacture may be linked together to the benefit of every interest concerned and of the Nation as a whole."

It is also contemplated that the Institution will "provide an authoritative body with whom the Government could consult on appropriate technical questions, especially in emergency." Meetings are to be held and papers presented in the interest of professional contact and technical advancement.

Compilation of Research Projects in Agricultural Engineering

UNDER THE sponsorship of the Committee on Agricultural Engineering Extension of the American Society of Agricultural Engineers, and with the cooperation of the Office of Experiment Stations of the U. S. Department of Agriculture, there has been compiled an up-to-date list of active research projects in or related to agricultural engineering at the state agricultural experiment stations. It is available in mimeograph form and comprises the names of several hundred projects arranged under eight main headings and more than sixty subheadings. Only a limited number of copies of this list are available. The price is 25 cents per copy (stamps or coin), and copies may be obtained from the Secretary of the Society at St. Joseph, Michigan.

(News continued on page 288)



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INASMUCH as a blasting cap is designed and intended to set off high explosives . . . no blasting cap can ever be called absolutely safe.

The new Atlas Manasite Blasting Cap, however, gives the user of explosives a much greater margin of safety than is possible with any detonating cap in common use.

Atlas Research determined to produce a blasting cap much less sensitive to external shock or impact. Success has now been attained in the use of nitromannite as an initiating compound.

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Chicago, Ill.	Knoxville, Tenn.	Philadelphia, Pa.	Salt Lake City, Utah	Tamaqua, Pa.
Denver, Colo.	Los Angeles, Calif.	Picher, Okla.	San Francisco, Calif.	Wilkes-Barre, Pa.

ATLAS

EXPLOSIVES

CHEMICALS ATLAS EXPLOSIVES

S. H. McCrory Bereaved

MRS. Blanche S. McCrory, wife of S. H. McCrory, chief of the Bureau of Agricultural Engineering, U. S. Department of Agriculture, and a past-president of the American Society of Agricultural Engineers and the first recipient of the John Deere Gold Medal to be awarded him by the Society next month, passed on May 27 at the George Washington University Hospital in Washington.

Mrs. McCrory was a native of Iowa and an active leader in club work in Washington, her principal interest being in the Daughters of the American Revolution, which she served as an officer in several high positions, including that of state historian. Besides her husband, Mrs. McCrory is survived by two daughters, Ruth R. and Dorothy E. McCrory, and a sister and five brothers.

What Agricultural Engineers Are Doing

(Continued from page 279)

will not be satisfactory for mechanical blocking. However, mechanically blocked plots are included on some of the single-seed plantings.

* * *

E. D. Gordon reports that one series of tests has been completed in which a conventional type of disk harrow having two opposed sets of disks of four each was used. The disk unit floats so that it is necessary to measure the average penetration. The longitudinal and vertical components of draft are also measured. The imposed factors are angle, speed, weight on the disk, and the moisture and apparent specific gravity of the soil. For this particular disk, which was an 18-inch disk spaced 6⅝ inches, the factor of disk angle setting appeared to have the greatest direct influence on penetration. For a given angle the factor of speed has an inverse effect on penetration. This is a part of a study of the draft requirements of tillage tools. Tests are at present under way on the notched disk, using the same arrangement as above. It is contemplated that others having different spacings and depth of cut will be tested.

* * *

I. F. Reed reports the data obtained at the Farm Tillage Machinery Laboratory, for plow reactions plotted against speed, fit parabolic curves very closely. Studying the curves produced shows a very high correlation between the values for the constants *a, b,* and *c,* and the soil conditions, as measured by the apparent specific gravity and moisture content of the soil in the share, in parabolic equations of best fit. Studies are now under way to determine and measure the effects of changing the angle between the moldboard and landside for two shapes of bottoms.

* * *

Manufacturers of plows and other tillage tools are much interested in the results being obtained at the Farm Tillage Machinery Laboratory at Auburn, Ala. One company is building a bottom based on their experiences and the results of tests made at the laboratory, and are planning to send this new bottom to the laboratory for test as soon as it is completed. Several other companies have requested information on special bottoms or are making arrangements to make cooperative tests on their equipment.

Extension Agricultural Engineers Classified

A MIMEOGRAPHED directory of agricultural engineering extension workers in public service in the United States has recently been received from S. P. Lyle, senior agricultural engineer, U. S. Department of Agriculture. It groups the workers by states and shows their major and minor subject matter fields.

Livingston's Work Expanded

UNTIL recently L. F. Livingston—a past-president of A.S.A.E.—was manager of the agricultural extension section of the explosives department of the E. I. du Pont de Nemours & Company; however, he is now manager of the agricultural extension division of the company as a whole, which involves all products of the company having an application in agriculture. He writes that while his work changes somewhat, he is "still just an agricultural engineer."

Personals

V. R. Hillman has recently been appointed acting project manager of the Va-1 Project of the U. S. Soil Conservation Service at Danville, Virginia.

L. F. Livingston, manager, agricultural extension section, E. I. du Pont de Nemours & Co., and a past-president of ASAE, is now serving a term as one of the vice-presidents of The American Forestry Association.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

A. Kirk Crawford, research fellow, Iowa State College, Ames, Iowa.

J. Tim Dudley, Union Hall, Virginia.

J. C. Ferguson, cotton gin specialist, agricultural extension service, North Carolina State College, State College Station, Raleigh, N. C.

Merritt V. Penwell, assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Apartment 103 Close Inn, Spokane, Wash.

TRANSFER OF GRADE

Frank Adams, professor of irrigation investigations and practice, University of California, Berkeley, Calif. (Mail) 302 Giannini Hall. Transfer from Member to Fellow.

Student Branch News

OHIO

ON APRIL 7 the Ohio Student Branch of the A.S.A.E. sponsored a lecture and demonstration on "Short Wave Radiation and Its Application to Agriculture" which was given before the students and faculty of the Ohio State University. Dr. Samuel G. Hibben, engineer-lecturer and director of lighting for the Westinghouse Electric and Manufacturing Company, presented the lecture and demonstration. This lecture is said to be one of the best ever given by the college of agriculture.

At the meeting of April 14, the members of the student branch elected the officers for the coming year and also discussed an inspection trip to Detroit, Michigan, on May 19 and 20, transportation for the trip to be furnished by the Branch. An inspection was made of the Ford, General Motors, and Cadillac plants, as well as scenic spots, during the two-day trip.

It was decided that the student branch challenge the faculty to a baseball game at the spring picnic which is to be held June 3.

Plans were made for a dinner meeting scheduled for May 12.

There is considerable talk concerning the possible delegates to the annual meeting of the Society this June, since about 30 students have been working hard all year to receive this honor. A point-credit system was set up and the four who win will certainly deserve the reward.

In connection with Engineers' Day, each department in the College of Engineering entered a float in a parade held May 13. The float for the Department of Agricultural Engineering depicted four ways in which an agricultural engineer can go through college. The first was a freshman with his nose to a revolving grindstone; the second, a sophomore riding a pony; the third, two juniors polishing apples; and last, but not least, was a senior riding a manure spreader. For the originality and presentation of the above float, the Engineers' Council presented the Agricultural Engineers with a large gold loving cup at the Engineers' Dance on May 14.—*Ralph E. Patterson, secretary.*

GEORGIA

THE REGULAR meeting of the Georgia Student Branch was held May 16 in the club room in Barrow Hall. Booker Garrard, president of the club, presided and presented Mr. R. H. Driftmier, who introduced the speaker of the evening, Dean Walter Cocking, of the department of education, University of Georgia.

Dean Cocking gave an interesting talk stressing the importance of young men taking up their life work in their own community rather than going to some distant place. He was given a fine welcome and a cordial invitation to visit the Branch at any time.

After the program Mr. Driftmier again congratulated the Branch on the student annual that recently came from the press. He said that many letters of commendation had been received.

The Branch voted to have its annual barbecue on May 20, at which time honor keys would be presented the outstanding seniors. The barbecue is one of the highlights of the club's activities and is always enjoyed by the students as well as the faculty of the department. It was also decided that the Branch would entertain the students of the agricultural college at a dance on May 21.

At one of the previous meetings the Branch elected Joe Hawkes as a delegate to attend the A.S.A.E. annual meeting in California this June.

A nominating committee was appointed to consider officers for the fall quarter of next year. The election of officers will be held at the next regular meeting of the Branch.—*Joe Hawkes, scribe.*

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, principal agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

EVALUATION OF CERTAIN FACTORS AFFECTING THE COST OF USING UTENSILS ON ELECTRIC HEATING UNITS, *M. M. Monroe.* Maine Sta. Bul. 386 (1937), pp. 53-155, figs. 23. The author studied the effect of the width of the pan in relation to that of the heating unit, the magnitude of variations in efficiency caused by differences in area of contact, the relative importance of contact between the utensil and the heating surface and the economy of black-bottom utensils as affected by the type of heating unit, the effect of the thermal efficiency of the utensil and heating unit upon the time of maintaining boiling with stored heat, the effect of polished aluminum v. black sides and cover and of the depth of the pan upon heat retention of a utensil, and of the design of a cover upon the amount of water evaporated during heating to boiling and during maintenance of boiling. A tentative study was also made of the relative economy of using duplicate and triplicate sets of saucepans on the same unit and of a "waterless" and a "well" cooker.

The findings are summarized separately for (1) the investigator of thermal efficiency of utensils used on electric heating units, (2) the manufacturer of cooking utensils and of electric heating units, and (3) the housewife as a guide to utensil selection. The last summary is an elaboration of the material contained in the bulletin noted above.

A supplement presents data on the differences in efficiency of utensils and heating units in terms of watt-hours and time required to heat the water and in the amount of water evaporated with a given heat input and in a given length of time during the maintenance of boiling.

COMPARATIVE COSTS AND EFFICIENCY OF STATIONARY VS. PORTABLE SPRAYING, *C. L. Burkholder.* Indiana Sta. Bul. 415 (1936), pp. 20, figs. 10. A stationary spray plant covering 45 acres, installed in 1930 in the Purdue orchard at Bedford, and portable equipment used in the same orchard were accurately compared as to costs. The data indicated that the entire cost of the stationary plant could be paid in 5 yr by the savings in the cost of applying the sprays. In addition, the permanent equipment was in good condition at the close of 6 yr, whereas the portable outfits were practically worn out. With special equipment, such as long-distance guns, stationary equipment gave satisfactory control of codling moths in the tops of trees. Before securing this additional equipment, the station found that the portable outfits were more effective in the tops of the trees. The control of apple scab was equally good with both types of spraying. The details in the planning, construction, and operation of the stationary plant are presented.

COLD STORAGE TESTS OF GRAPEFRUIT AND ORANGES, *J. F. Wood, W. H. Friend, and G. H. Godfrey.* Tex. Farming and Citric., 14 (1937), No. 2, p. 7. Comparisons made by the Texas Experiment Station of 34 and 44 F for the storage of citrus fruit indicated that with the grapefruit the higher temperature is somewhat preferable, but the results were not favorable at either point. The Marsh grapefruit held up better at 34 than did the Little River. Of different washes used on the Foster Pink grapefruit, a soap wash gave the best results. Valencia oranges stored at 34 and 44 kept 100 per cent and 99+ per cent sound, respectively, from March 18 to May 10, and treatment with the various washes had no marked effect. Aluminum foil and cellophane wraps kept oranges in perfect condition, as compared with about 90 per cent sound with the controls. The lining of boxes with wrapping paper of various kinds improved the keeping of Valencia oranges.

THE EFFECT OF CERTAIN NITROGENOUS COMPOUNDS ON THE RATE OF DECAY OF WOOD, *H. Schmitz and F. Kaufert.* Amer. Jour. Bot., 23 (1936), No. 10, pp. 635-638. In this study at the University of Minnesota, varying amounts of asparagine and ammonium nitrate were supplied to cultures of sawdust of the heartwood and sapwood of Norway pine (*Pinus resinosa*) and paper birch (*Betula papyrifera*) and the rate of decay determined after inoculation with *Lenzites trabea* and *Polystictus versicolor.* Asparagine definitely increased the rate of decay of *Pinus resinosa* heartwood and sapwood by *L. trabea* and of *B. papyrifera* sapwood by *Polystictus versicolor* without affecting the rate of decay by the latter in birch heartwood. Except in one case where as much as 5 per cent ammonium nitrate was added to *Pinus resinosa* heartwood, the addition of this material to both kinds of sapwood and heartwood failed to increase significantly the rate of decay. These results point to the probable importance of the amount and availability of organic nitrogen as a factor in determining the rate of wood decay.

METHODS OF LOCATING SALT-WATER LEAKS IN WATER WELLS, *P. Livingston and W. Lynch.* U. S. Geol. Survey, Water-Supply Paper 796-A (1937), pp. II + 20, pls. 9, figs. 5. This paper presents various methods that have been used in studying the problem of locating salt water leaks in water supply wells. Four general methods of detecting salt water leaks have been used. In the pumping method, samples taken at measured time intervals while the well is being pumped show by their progressive change in salinity if salt water is being drawn in. In the velocity method, which is suitable for use only in artesian wells, a current meter lowered into the well indicates the location of possible salt water leaks by determining the levels at which there are changes in the rate of upward movement of the water. In the sampler method a container lowered into the well brings up a sample from any depth desired for analysis of its chloride content. The electric conductivity method, for which special apparatus was designed, has been used successfully in the Winter Garden area and Kleberg County, Tex., and in Sarasota County, Fla. The procedure in this method was to lower a pair of insulated electrodes into the well and measure the resistance of the water between them with the Wheatstone bridge or, in waters low in chloride, to apply a direct current of low voltage and measure the current flowing between the electrodes by means of a milliammeter. The instruments showed a marked increase in the conductivity of the water as the electrodes passed from fresh to salt water in the well, leaving no doubt as to the location of the leaks.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE MASSACHUSETTS STATION, *C. I. Gunness et al.* Massachusetts Sta. Bul. 339 (1937), p. 8. Progress results are briefly presented of investigations on low-lift pumps for cranberry bogs, milk cooling, cranberry storage, brooder development, and apple storages.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE IDAHO STATION, *H. Beresford.* Idaho Sta. Bul. 221 (1937), pp. 12-16, fig. 1. The progress results are briefly presented of investigations on irrigation, drainage, and land development; plow development for pea weevil control; high-speed combines for peas; alcohol-gasoline blends for engine fuel; farm building failures; earth type potato storage cellars; and rural electrification.

THEORY OF LUBRICATION, *M. D. Hersey.* New York: John Wiley & Sons; London: Chapman & Hall, 1936, pp. XI + 152, figs. 24. This volume is based on a series of lectures on the mechanics of lubrication presented at Brown University, Yale University, and the Massachusetts Institute of Technology. These lectures aimed to give the scientific background of modern lubrication. In conformity therewith this volume contains chapters on viscosity and its relation to friction, the classical hydrodynamic theory, dimensional theory with applications, temperature rise in bearings, and the problem of oiliness.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE ARIZONA STATION, Arizona Sta. Rpt. 1936, pp. 19-29, fig. 1. Progress results are briefly presented of investigations on precipitation on the drainage area of the Santa Cruz River above Rillito, Ariz., relation of stream runoff to rainfall, flood danger on the bottomland, ground water, ground-water law, adjudication of water rights within the Santa Cruz Basin, preferential water rights, valley terraces and their relation to ground-water supplies, refinancing of defaulting irrigation and drainage districts, adobe structures, creosoting tamarisk for fence posts, and control of high soil temperatures in citrus orchards. *(Continued on page 292)*

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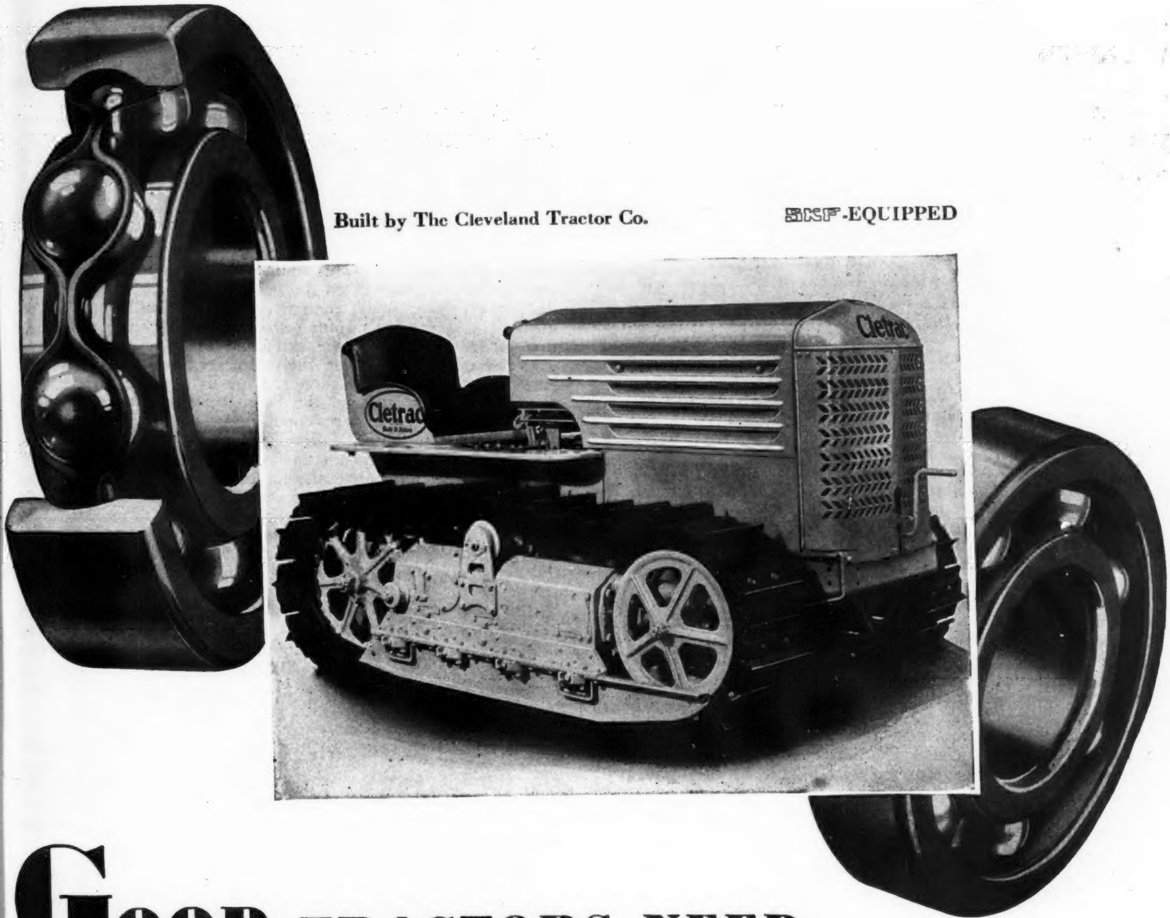

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The Relationship between Tree-Growth and Stream-Runoff in the Truckee River Basin, California-Nevada, *G. Hardman.* Amer. Geophys. Union Trans., 17 (1936), pt. 2, pp. 491-493. This is a brief contribution from the Nevada Experiment Station presenting results of studies published in complete form in Bulletin 141 of the station.

Flood on Republican and Kansas Rivers, May and June 1935, *R. Follansbee and J. B. Spiegel.* U. S. Geol. Survey, Water-Supply Paper 796-B (1937), pp. II + 21-52, pls. 6, fig. 1. The character and consequences of this flood are described and illustrated, and related data are reported.

Construction of Private Driveways, *D. M. Beach.* U. S. Dept. Agr., Misc. Pub. 272 (1937), pp. [1] + 30, figs. 26. Practical information is given on the subject.

Bibliography on Highway Lighting, Compiled by *M. A. Wilson.* U. S. Dept. Agr., Misc. Pub. 279 (1937), pp. [1] + 30. This bibliography has been compiled from the catalog of the Bureau of Public Roads supplemented to some extent by material from other sources. It includes references to books, periodicals, and publications of societies throughout 1936.

Investigations on Machinery Used in Spraying.—IV Nozzles, *C. Davies and G. R. B. Smyth-Homewood.* Jour. Southeast, Agr. Col., Wye, Kent, No. 40 (1937), pp. 50-57, figs. 9. In a further contribution to the subject variations in the details of nozzle construction are discussed in the field and laboratory tests. No conclusions are drawn.

Agricultural Engineering: A Selected Bibliography, Compiled by *D. W. Graf.* U. S. Dept. Agr., Bur. Agr. Engin., 1937, pp. 373. This mimeographed bibliography lists principally publications of the U. S. Department of Agriculture, the state agricultural experiment stations, and the state extension services from their beginning through 1935.

Agricultural Engineering Investigations by the New Hampshire Station, *W. T. Ackerman, T. B. Charles, G. M. Foulkrod, A. E. Tepper, R. C. Durgin, and H. N. Colby.* New Hampshire Sta. Bul. 296 (1937), pp. 17-19, 20, 21. The progress results are briefly presented of investigations on heat requirements for brooding chicks, the use of the V-belt for the power grindstone, electric washing and sterilizing equipment for dairy utensils, electric fence controller, and alarm systems on poultry fencing.

Recent Developments in Grass Drying, *G. P. Pollitt.* Jour. Roy. Soc. Arts, 85 (1937), No. 4414, pp. 734-743. The author briefly reviews experience by himself and others in the artificial drying of grass and hay. It is significant that under British conditions the production of artificially dried hay at costs ranging from £4 to £5 per ton ($20 to $25 per ton) is considered a profitable practice, using drying equipment the first cost of which ranges from $2,500 to as high as $9,000, depending upon local conditions.

Preservative Treatment of Green Southern Yellow-Pine Lumber with Zinc Chloride and Zinc Chloride-Sodium Bichromate, *E. R. Boller.* Amer. Wood-Preservers' Assoc. Proc., 33 (1937), pp. 262-278, figs. 3. This investigation indicated that green southern yellow pine lumber can be impregnated satisfactorily with zinc chloride-sodium bichromate or straight zinc chloride by conditioning with either steam or water at 260 F, subjecting it to vacuum and pressure, and treating with a 5 per cent solution of the preservative at 165 F. The green pine was heated somewhat more rapidly with water than with steam.

It was also indicated that green pine can be treated satisfactorily with zinc chloride in a somewhat shorter time by conditioning it with the treating solution at 260 F, subjecting to vacuum and pressure, and treating with a 5 per cent salt solution at from 220 to 260 F. A fairly satisfactory treatment with zinc chloride was obtained without application of vacuum following the conditioning period.

By applying a final vacuum it was possible to lower appreciably the moisture content of the treated wood. Generally, treatment reduced the moisture content when the initial moisture content of the green pine was high but raised it when the initial content was relatively low.

Treatment of green pine had no effect upon its behavior in the kiln-drying operation. There was some indication that treatment would reduce deterioration of the pine when dried under adverse conditions.

Treatment of green pine by the methods described and subsequent kiln drying did not affect important strength properties of the material sufficiently to require consideration in stress calculations.

The Principles of Motor Fuel Preparation and Application, I, II, *A. W. Nash and D. A. Howes.* New York: John Wiley & Sons, 1935, vols. 1, pp. XIV + 538, figs. 125; 2, pp. XIV + 523, figs. 139. This contribution is in two volumes. Volume 1 contains chapters on the principles of distillation; the production of motor fuels from petroleum by distillation; the production of motor fuels from petroleum by cracking; the production of motor fuels by the extraction of gasoline from natural gas; the refining of motor fuels; storage, insurance, and distribution; benzole, its production and use as a motor fuel; the production of motor fuels by the hydrogenation process as applied to mineral oils and coals; alcohol fuels; and synthetic fuels and other auxiliary supplies of motor spirits. Volume 2 contains chapters on analysis and examination of motor fuels; sulfur in motor fuels from the automotive standpoint; the formation, estimation, and significance of gum in motor fuels; internal combustion engines; the effect of fuel volatility characteristics on engine performance; knock ratings; motor fuel specifications and properties of motor fuels marketed in different countries; aviation fuels; and automotive Diesel engines and Diesel oils.

Electric Power for Irrigation in Humid Regions. C.R.E.A. Bul. [Chicago], 7 (1937), No. 2, pp. 23, figs. 30. Pertinent technical information on the subject is brought together in form for use by engineers in this publication. An appendix gives constants and conversion factors and a bibliography of selected references on irrigation is included.

Institutional and Other Small Water Treatment Plants to Meet Unusual Conditions, *F. R. Shaw.* Amer. Jour. Pub. Health, 27 (1937), No. 5, pp. 444-452, figs. 4. This is a contribution from the U. S. Public Health Service. It gives technical information on the design of small water treatment plants.

Engineering Analysis of Electric Uses on the Farm, *E. A. White.* C.R.E.A. News Letter [Chicago], No. 15 (1937), pp. 12-18, figs. 3. This analysis, the results of which are presented in tabular and graphic form, is based on data collected on 46 Ohio farms. The first objective was to obtain a range of energy use and the second objective was to select farms representing the chief types of agriculture in the territory. On this basis, dairy, fruit, truck, poultry, dairy and poultry, and general farms were included.

It is concluded that different methods of selecting farms for an engineering analysis of electric uses may be used. It is considered important that the engineering method of analysis applied to electric use as developed by farmers promises to afford information whereby performance may be checked, efficiency improved, and the economic and social benefits of electric service be expressed in units which can be universally accepted.

Refrigerated Apple Storages, *C. I. Gunness.* C.R.E.A. News Letter [Chicago], No. 15 (1937), pp. 19-22, figs. 5. In a brief contribution from the Massachusetts Experiment Station data are presented on the construction, operation, and cost of operation of refrigerated apple storages under Massachusetts conditions.

Uses of Insect-Electrocuting Light Traps, *W. B. Herms and J. K. Ellsworth.* C.R.E.A. News Letter [Chicago], No. 15 (1937), pp. 25-29, figs. 8. This is a brief contribution from the California Experiment Station in which the progress results are briefly presented of studies on the development of insect-electrocuting light traps in California. It is pointed out that one of the principal objectives of this investigation is to develop the control of insect pests which will obviate poisonous residues. Data are given briefly on the control of the grape leaf hopper, artichoke plume moth, codling moth, insects of tomatoes, mushrooms, and dried fruit, and the lima bean pod borer.

Human and Physical Resources of Tennessee.—V, Minerals and Mining, *C. E. Allred, S. W. Atkins, and W. E. Hendrix.* Tenn. Agr. Col., Agr. Econ. and Rural Sociol. Dept. Monog. 44 (1937), pp. VI + 54-69, figs. 6. This is one of a series of monographs dealing with the principal economic, social, and civil aspects of Tennessee. It gives general information on the mineral and mining resources of the State. *(Continued on page 294)*

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PROLONGING THE FLOWERING PERIOD OF CHRYSANTHEMUMS WITH THE USE OF SUPPLEMENTARY ILLUMINATION, *G. H. Poesch.* C.R.E.A. News Letter [Chicago], No. 15 (1937), pp. 34, 35. In a contribution from the Ohio Experiment Station results are briefly reported of studies which showed that supplementary additional light applied before August 15 and discontinued October 1 was most effective in retarding flower bud differentiation of the chrysanthemum. Mazda lamps installed to emit at least 3 foot-candles at the furthermost point from the lamp were more satisfactory than daylight, medium and light blue, and mercury lamps. Increasing the day length to 15 hr is sufficient to retard flowering. Production of pompons is greatly reduced by retarding the bud formation. The number of flowers per spray was greatly reduced. Varieties differ greatly in response to this treatment. Standard and disbud varieties can be retarded with greater financial success than pompons. Some of the better varieties were found to be Monument, Marie DePetris, Crimson Glow, December Glory, Orchid Beauty, Cordova, and Rolinda. The strong-growing varieties were found most adaptable for use in retarding studies. Plants to be retarded should be propagated in June and planted in July. The last pinch should be made shortly before applying additional light.

RURAL COOPERATIVE TELEPHONES IN TENNESSEE, *C. E. Allred, T. L. Robinson, B. H. Luebke, and S. R. Neskaug.* Tennessee Sta., Agr. Econ. and Rural Sociol. Dept. Monog. 45 (1937), pp. III + 34, figs. 3. This monograph presents briefly the conclusions regarding rural telephones in Tennessee derived from data collected by personal visits to officials of functioning organizations and by the questionnaire and survey method. It includes an account of failures as well as accomplishments.

AMERICAN FARM BUREAU FEDERATION, INSTITUTE OF IRRIGATION AGRICULTURE, Sixth Annual Conference, Corvallis, Oregon, March 30, 31, and April 1, 1937 [Chicago: Amer. Farm Bur. Fed., 1937], pp. [1] + 76. The proceedings of this conference include special papers on Forecasting the Irrigation Water Supply by Snow Survey, by R. A. Work (pp. 5-9); Irrigation Practice as a Factor in Soil Erosion, by H. E. Reddick (pp. 11-19); A Discussion and Demonstration of the Fundamentals of Soil and Water Relations as Applied to Irrigation Practice, by J. B. Brown (pp. 19-24); The Resettlement Program as It Will Affect Western Irrigation Projects, by W. E. Packard (pp. 27-35); Artificial Recharging of Underground Water Supplies, by A. T. Mitchelson (pp. 42-49); Correlation of Range Land Use With Irrigation Project Needs, by F. R. Carpenter (pp. 52-55); Power Development on Federal Reclamation Projects, by G. Sanford (pp. 56-64); and Factors That Determine the Feasibility of a Reclamation Project, by W. L. Powers (pp. 65-72).

A DEVICE TO ASSIST IN MOWING KUDZU, *E. G. Diseker.* Alabama Sta. Leaflet 16 (1937), pp. 4, figs. 5. An attachment to a standard mower is described and illustrated, the purpose of which is to assist in cutting the long, tough vines of the kudzu plant.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE MISSOURI STATION, *J. C. Wooley, M. M. Jones, G. W. Giles, P. Doll, M. F. Miller, and H. H. Krusekopf.* Missouri Sta. Bul. 387 (1937), pp. 17, 18, 91, 92. The progress results are briefly presented of investigations on the efficiency of tillage methods for growing corn, the housing of laying hens, and on soil erosion control.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE ILLINOIS STATION. Illinois Sta. Rpt. 1936, pp. 110, 219-242, figs. 5. The progress results are briefly presented of investigations by C. W. Crawford, E. T. Robbins, and W. M. Dawson on the mechanical measurement of the pulling ability of horses; on the use of electricity on farms, by E. W. Lehmann and A. L. Young; farm sewage disposal, by Lehmann and A. M. Buswell; tractor fuels and use of high-compression tractor engines, both by R. I. Shawl; covering devices on plows, by Young, Shawl, and T. Cleaver; soil erosion control, by Lehmann and R. C. Hay; use of the small combine, by Young, Shawl, W. M. Hurst, W. R. Humphries, and Cleaver; development of machinery for artichoke culture, by Lehmann and Shawl; hay and grain drying, by Lehmann, R. H. Reed, W. L. Burlison, and G. H. Dungan; stationary spraying-plant design, by Lehmann, Reed, H. W. Anderson, and R. L. McMunn; development of apple-washing machinery, by Reed; development of farm-waste gas plants, by Buswell, Lehmann, and E. E. DeTurk; ventilation of poultry houses, by W. A. Foster and L. E. Card; and weed-control machinery, by C. W. Veach.

SOIL EROSION INVESTIGATIONS BY THE NORTH CAROLINA STATION, *F. O. Bartel.* North Carolina Sta. Rpt. 1934, pp. 15-26. The progress results are briefly reported of soil erosion research at the station, and a summary of the results of 16 different engineering experiments in soil erosion control is presented. These relate to spacing for short graded terraces on steep slopes, spacing of graded terraces on moderate slopes, grades for short terraces, effect of spacing upon long variable graded terraces, grades for long terraces, length of terraces with uniform grades, spacing for short level terraces on steep land, possibility of retaining all of the rainfall on terraced land, benefits derived from terracing, cost of terrace construction, design of farm machinery for operation on terraced land, use of check dams, soil movement on terraced and unterraced land, runoff losses from terraced and unterraced watersheds, effectiveness of subsoiling in preventing soil erosion, and erosion control in terrace outlets.

A STUDY OF THE OPERATION OF TRACTORS AND IMPLEMENTS UNDER FARM CONDITIONS, *H. E. Murdock.* Montana Sta. Bul. 344 (1937), pp. 102, figs. 92. The results of studies over the past 7 yr relating to the mechanical factors involved in the operation of tractors and implements are summarized. The results show that implements should be operated as deep as is necessary to do a good job of weed killing but no deeper. Tractors operate most efficiently near their rated capacity. For economy, therefore, they should always be loaded up to nearly a full load. Light draft implements should be hitched in gangs of two or more to make an economical load for the tractor. By matching the load to the tractor the best speed for the operation may be used. If the draft is too light, a speed too high for the implements may be necessary to get efficient use of the power, whereas, if the draft is too great it may cause excessive slip with too slow speed. It is important that the proper carburetor adjustment be maintained. Excessive use of fuel may result from improper setting of the valves that regulate the ratio of fuel to air.

SOIL EROSION AND WATER CONSERVATION INVESTIGATIONS BY THE KANSAS STATION, *F. G. Ackerman.* Kansas Sta. Bien. Rpt. 1935-36, pp. 123, 124. Progress results of the investigations conducted in cooperation with the USDA Soil Conservation Service are briefly presented.

GROUND WATER IN AVRA-ALTAR VALLEY, ARIZONA, *D. A. Andrews.* U. S. Geol. Survey, Water-Supply Paper 796-E (1937), pp. II + 163-180, pls. 4, fig. 1. This report relates to the geography, geology, ground-water conditions, ground-water developments, and quality of ground water of an area in Pima County, southeastern Arizona, of nearly 1,400 sq mi.

The demands for water in the area are almost wholly for domestic needs and stock, with only limited uses for irrigation. Water in moderate amounts is obtained from wells in the lower alluvial lands at depths of about 150 to 350 ft. A few wells on the higher alluvial slopes have been drilled to the water table at 550 to 800 ft. In some parts of the pediment zone small amounts of water are obtained at depths of about 20 to 100 ft in disintegrated rock. In most places the ground water is of good quality, but in a few places in the pediment zone where sandstone and shale of Cretaceous age are penetrated, the water is hard and contains undesirable quantities of soluble salts.

SOME VARIABLES IN EXPERIMENTAL SEEDERS, *G. P. McRostie et al.* Sci. Agr., 17 (1937), No. 8, pp. 523-528, figs. 3; Fr. Abs., p. 528. Experiments are reported which were conducted at the University of Manitoba with four types of hand seeders, of which two were common commercial types and two were models developed for experimental seeding. The machines were tested for uniformity of seeding and accuracy of total delivery of seed. The commercial seeders were also checked for variation in quantity of seed delivered when the fullness of the hopper was altered and when the speed of operation was changed. In general, the new continuous belt seeder proved to be the most satisfactory for the seeding of either head rows or rod rows of wheat. There was a definite influence of speed of operation on the amount of seed delivered in the case of the Planet Junior seeder. The slower speed in all cases resulted in a larger delivery of seed. No significant influence was secured by varying the amount of seed in the hopper. With the Columbia seeder the reverse condition was encountered. The speed of operation had no significant influence on the quantity of seed delivered, but increasing the amount of seed in the hopper resulted in apparently significant increases in the amount of seed delivered. None of the seeders tested were as satisfactory in seeding oats or barley as they were in the case of wheat.

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PLANS OF FARM BUILDINGS FOR NORTHEASTERN STATES. U. S. Dept. Agr., Misc. Pub. 278 (1937), pp. 128, figs. 118. These plans have been compiled by the Bureau of Agricultural Engineering and the Extension Service in cooperation with the Connecticut, Massachusetts, Pennsylvania, and Rhode Island State Colleges; and the University of Delaware, Maine, Maryland, New Hampshire, Vermont, and West Virginia, Rutgers University, and Cornell University.

Correction Notice

IN THE paper "Modern Connectors in Wood Construction," by John A. Scholten, published in AGRICULTURAL ENGINEERING for May 1938, an error appears on page 202. The safe load for a 4-in split ring connector perpendicular to the grain is given as 4,000 lb. The correct figure is 8,400 lb, which is 70 per cent of the safe load parallel with the grain.

Literature Received

"LEGUME AND GRASS SILAGE" is a bulletin publishing the results of a survey of methods and results used in making it on 380 northeastern farms. Frank H. Hamlin (Mem. A.S.A.E.) and dairy husbandry specialists from four states were members of the committee responsible for the survey and report. They were appointed by the chairman of an eastern feed conference in November, 1937. Results of their survey are published in New Jersey Agricultural Experiment Station Bulletin 643, and reprinted as Bulletin 79 of the Papec Machine Co. It is also to be reprinted by several state colleges in the East. The report covers the ensiling of various legumes, grasses, and combinations of two or more of these crops; harvesting methods; methods of adding molasses and phosphoric acid; feeding methods and results; and costs.

S. A. E. HANDBOOK, 1938 edition. XXXV + 776 pages, 5¾x8½ in. Published by the Society of Automotive Engineers, Inc., New York City. Complete, up-to-date information on the standards policy, standards, new and revised standards, organization and procedure. Standards published are grouped according to subject matter as follows: Units, Parts, and Fittings; Materials, Processed; Materials, Fabricated; Screws, Bolts, and Washers; Tests, Ratings, and Codes; Transportation and Maintenance; Tools and Production Equipment; Nomenclature and Definitions; and Miscellaneous Specifications. Price to non-members of S.A.E., $5.00.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL ENGINEERS wanted to sell lightning protection equipment and fire alarm systems. Dealer arrangement, or opportunity available to sell for the factory, or for an established dealer. Opportunity to make a profit and to render a worthwhile fire prevention and safety service. PO-121

POSITIONS WANTED

MECHANICAL ENGINEER, with eighteen years' experience supervising engineering work on heavy farm machinery, is available for a position of a similar nature. PW-288

AGRICULTURAL AND CHEMICAL ENGINEER, with nine years experience in agricultural engineering teaching and research and two years industrial experience, desires position in either teaching or research. Age 35. Married. PW-289

ENGINEER, electrical and mechanical engineering graduate with master's degree, several years experience teaching in mechanical engineering and agricultural engineering, and some research and industrial experience, desires employment offering a larger opportunity. Now employed. Age 34. Married. PW-290